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(OSWER Directive 9355.0-7B)
March 1987

DATA QUALITY OBJECTIVES

FOR REMEDIAL RESPONSE ACTIVITIES

Example Scenario

(RI/FS Activities at a Site with Contaminated Soils and Ground Water)

Prepared for:

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and
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NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This Data Quality Objectives For Remedial Response Activities (Example Scenario RI/FS Activities at a Site with Contaminated Soils and Ground Water) provides an outline of the process for development of data quality objectives (DQOs) for RI/FS activities under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA). DQOs are qualitative and quantitative statements specified to ensure that data of known quality are obtained during remedial response activities to support an Agency decision. This document is intended to demonstrate the development of data quality objectives (DQOs) for an example RI/FS activity. The example presented herein should be utilized in conjunction with the companion manual, Data Quality Objectives For Remedial Response Activities (Development Process) in developing DQOs for site specific applications.

This example and the companion guidance manual have been prepared under the direction of the Office of Solid Waste and Emergency Response (OSWER). The documents were prepared in accordance with the National Oil and Hazardous Substance Pollution Control Contingency Plan (NCP) final rule, published in the Federal Register November 20, 1985 and effective February 18, 1986. These documents will be updated in the near future to be consistant with SARA and the new NCP. These documents are part of a series of documents which includes the following titles:

- Guidance on Remedial Investigations Under CERCLA (EPA 540/G-85/002)
- Guidance on Feasibility Studies Under CERCLA (EPA 540/G-85/003)
- Superfund Remedial Design and Remedial Action Guidance (OSWER Directive 9355.0-4A)
- Compendium of Field Operations Methods (planned June 1987)
- Superfund Public Health Evaluation Manual (OSWER Directive 9285.4-1)
- Superfund Exposure Assessment Manual (OSWER Directive 9285.5-1)

Collectively, these documents provide guidance for the development and performance of technically sound and cost-effective remedial response activities which will support the program goals of both the Office of Emergency and Remedial Response (OERR) and the Office of Waste Programs Enforcement (OWPE). These documents are also available for use by state agencies and private parties conducting remedial response activities to ensure that their activities are consistent with the intent of CERCLA.

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ARAR	Applicable or Relevant and Appropriate Requirements
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund)
CDC	Center for Disease Control
CLP	Contract Laboratory Program
DQO	Data Quality Objective
EMSL-LV	Environmental Monitoring and Support Laboratory - Las Vegas
ESD	Environmental Services Division (of EPA)
FIT	Field Investigation Team
FS	Feasibility Study
GC/MS	Gas Chromatograph/Mass Spectrograph
HSL	Hazardous Substance List
LFI	Limited Field Investigation
MDL	Method Detection Limit
NBS	National Bureau of Standards
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NEIC	National Enforcement Investigation Center
NPL	National Priorities List
ORC	Office of Regional Counsel
PARCC	Precision, Accuracy, Representativeness, Completeness, Comparability
PRP	Potentially Responsible Party
QAMS	Quality Assurance Management Staff
QAPP	Quality Assurance Program Plan
QAPjP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RA	Remedial Action
RAS	Routine Analytical Service
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
RSCC	Regional Sample Control Center
S&A	Sampling and Analysis
SAS	Special Analytical Service
SMO	Sample Management Office
SRM	Standard Reference Materials
TAC	Technical Advisory Committee
TAT	Technical Assistance Team
TIC	Tentatively Identified Compounds
TSCA	Toxic Substances Control Act
VOC	Volatile Organic Compounds

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1 INTRODUCTION

DQO STAGES

RELATIONSHIP OF DQOs TO RI/FS EXECUTION

FORMAT AND PURPOSE OF DOCUMENT

1.0 INTRODUCTION

Data quality objectives (DQOs) are qualitative and quantitative statements specified to ensure that data of known and appropriate quality are obtained during remedial response activities. To ensure that the data generated during the remedial response activities are adequate to support Agency decisions, a clear definition of the objectives and the method by which decisions will be made must be established early in the project planning process. These determinations are facilitated through the development of DQOs.

Data quality objectives are specified for each data collection activity associated with a remedial response. The majority of data collection activities will be undertaken during the remedial investigation (RI) and additional data needs may be identified during the feasibility study (FS), remedial design (RD), and remedial action (RA).

The intent of this document is to illustrate, through a case study scenario, how development of DQOs is incorporated into RI/FS planning activities. The example describes RI/FS planning activities as the context for DQO development. However, the site and analytical values are hypothetical and, importantly, the example is not to be considered a complete description on how to develop a full RI/FS. Detailed guidance on RI/FS activities can be found in EPA policy and technical guidance documents, technical and scientific literature, and through experienced EPA and remedial contractor staff. The guidance document provides references for additional information at the end of each section.

In actual practice to date, RI/FS projects conducted under CERCLA have complied with the intent of the DQO process. DQOs have been informally incorporated as parts of sampling and analysis plans, quality assurance project plans, or work plans. The purpose of this example and companion manual (Data Quality Objectives For Remedial Response Activities - Development Process, EPA 1987) is to present a formal approach to DQO development and documentation. The DQO process outlined in this document serves as the basis for development of this example.

1.1 <u>DQO STAGES</u>

DQOs are developed using the following three-stage process:

- Stage 1 - Identify decision types
- Stage 2 - Identify data uses and needs
- Stage 3 - Design data collection program

Figure 1-1 identifies the major components in each of the DQO stages. These stages should be undertaken in an interactive and iterative manner whereby all the elements of the DQO process are continually reviewed and applied during execution of data collection activities. As such, DQOs are developed at the onset of a project and revised or expanded as needed based upon the results of each data collection activity. During the implementation of the DQO process, these stages occur in a natural progression and flow together without a formal stage delineation.

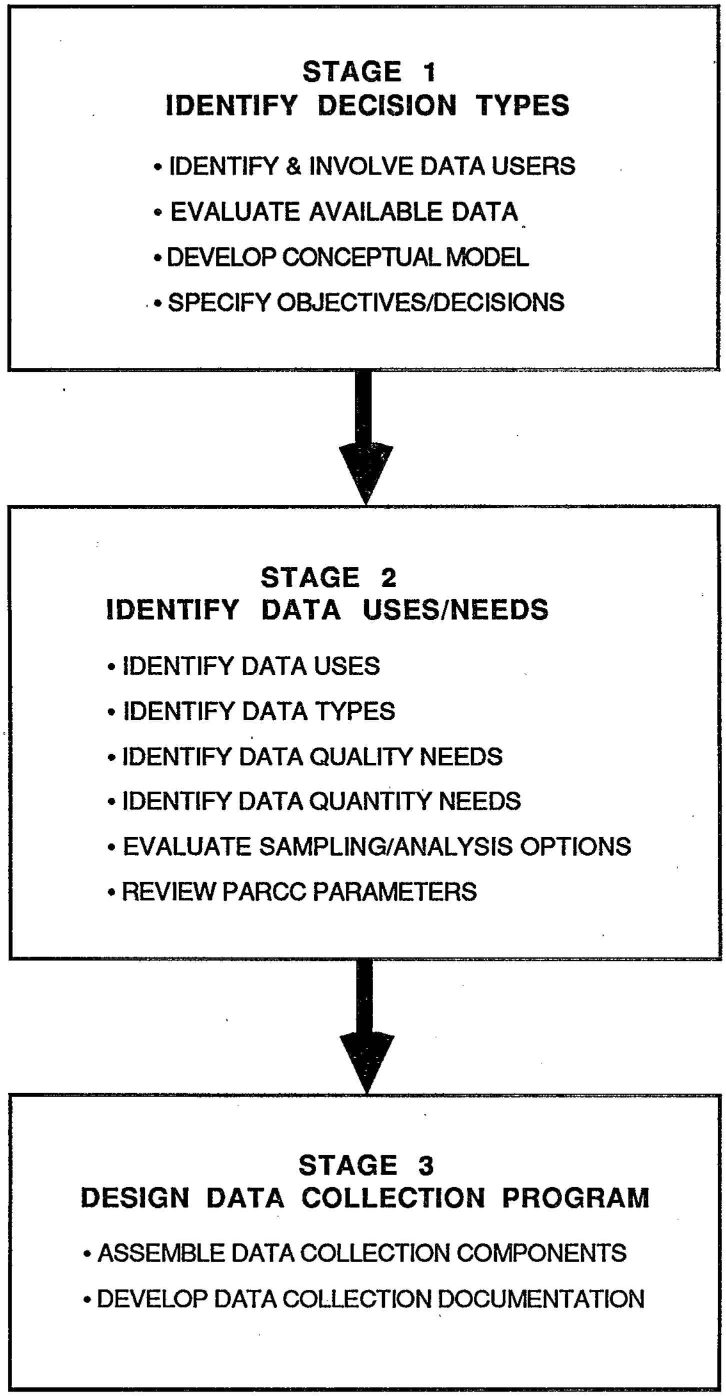


FIGURE 1-1
DQO THREE-STAGE PROCESS

1.2 RELATIONSHIP OF DQOs TO RI/FS EXECUTION

The overall objective of the RI is to determine the nature and extent of the threat posed by the release or threat of release of hazardous substances and to evaluate proposed remedies. The ultimate goal of the FS is to select the most cost-effective remedial alternative which mitigates threats to and provides protection of public health, welfare, and the environment, consistent with the NCP.

The quality and amount of data required to identify sources of contamination and delineate the extent of contamination with adequate certainty to select a remedial alternative will vary by site. In most situations it may not be possible to identify all data needs during the initial scoping activities. Rather, data needs will become more apparent as additional data are obtained and evaluated. Phasing of RI/FS projects is undertaken to accommodate this iterative process. By separating the RI into distinct phases, data can be collected and evaluated sequentially with a refinement and/or redefinition of data collection needs at the completion of each phase.

Figure 1-2 shows the relationship between the phased RI/FS approach and the DQO process. The DQO process is applied during scoping and following each data collection activity. Through the application of the DQO process, decisions regarding the need for additional data can be made and subsequent data collection activities designed.

It is important to realize that DQOs are an integrated set of thought processes which define data quality requirements based on the end use of the data. At no time during the RI/FS, RD or RA is a DQO deliverable required. Also, it is not required that the procedures for selecting an analysis or sampling option be discussed in the detail shown in this example. The example merely shows the type of analysis which must be performed to correctly select an option. The rationale for selection and the actual DQO will be documented in the sampling and analysis (S&A) plan in accordance with regional requirements.

1.3 FORMAT AND PURPOSE OF DOCUMENT

This document is intended to provide an example of the process of DQO development. The example is based upon an RI/FS for a hypothetical uncontrolled hazardous waste site with known soil and ground water contamination. Conditions and requirements will vary from site to site but the process remains the same.

This example document is organized in the following manner. Section 2.0 presents a brief summary of the example. Section 3.0 describes Stage 1 activities for the RI/FS scoping process. Section 4.0 describes DQO Stage 2 activities for the overall RI/FS. Section 5.0 describes Stage 2 and 3 activities for the first phase of the RI, while Section 6.0 describes Stage 2 and 3 for the second phase of the RI. Section 7.0 presents a brief overview and conclusion of the DQO development for the example site.

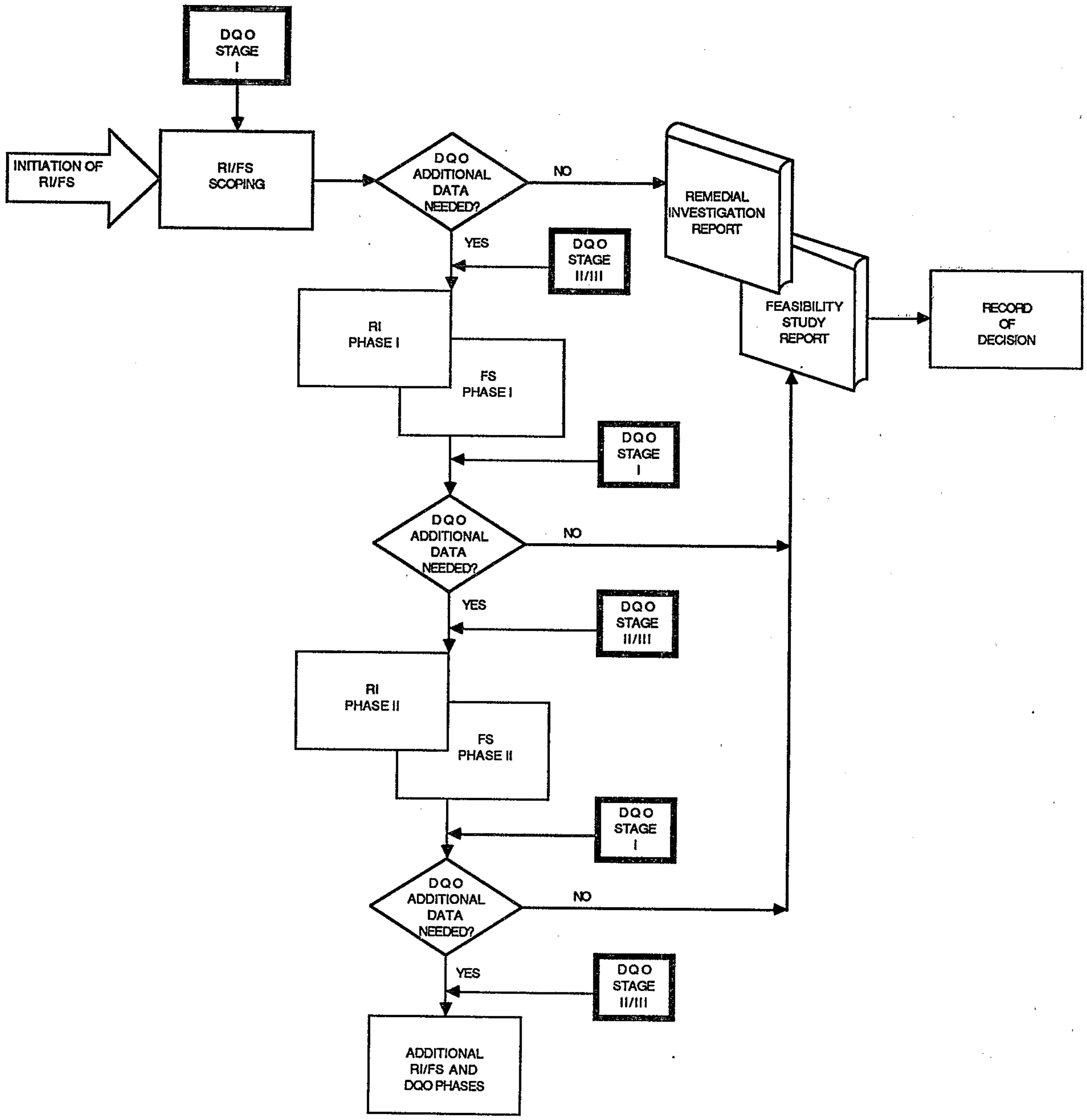


FIGURE 1-2
PHASED RI/FS APPROACH AND THE DQO PROCESS

2

SUMMARY OF DQO DEVELOPMENT EXAMPLE

STAGE 1 - IDENTIFY DECISION TYPES

STAGE 2 - IDENTIFY DATA USES/NEEDS

STAGE 3 - DESIGN DATA COLLECTION PROGRAM

2.0 SUMMARY OF DQO DEVELOPMENT EXAMPLE

This section provides a brief summary of the example to give readers a perspective on the overall process. Quite simply, what is shown in the example is the process of (1) identifying the objectives of the overall RI/FS and each of its components, (2) identifying the specific uses for which data must be collected and the data quality required for each use, and (3) developing a sampling and analytical plan to meet the RI/FS objectives in the most efficient and effective manner possible. To perform each of the above steps, the three-stage DQO development process is applied during the planning phase of the RI/FS. Figure 2-1 illustrates integration of the DQO process into the planning for the phased RI/FS in this example.

This summary is organized according to each of the DQO stages. The detailed discussion of the example is organized according to the RI/FS phases, showing how the DQO stages fit in to the normal sequence of events for an RI/FS.

2.1 STAGE 1 - IDENTIFY DECISION TYPES

Stage 1 of the DQO process takes place as part of RI/FS scoping. Through interaction with data users and evaluation of existing information, a conceptual model of the site is developed and objectives are set for further data collection and evaluation efforts (if needed) to meet remedial program goals. Stage 1 activities are resumed at the completion of each RI phase to evaluate new data, refine or revise the conceptual model as appropriate, and to set objectives for the subsequent phase. Stage 1 for the example site is discussed in detail in Section 3.0.

At the completion of Stage 1 activities, a conceptual model of a site has been developed showing clear evidence of contaminated soil and ground water. Potential contamination of private wells, which are screened within an unconfined aquifer, presents a health threat to nearby residents who rely on the wells for drinking water. The general layout of the site is shown in Figure 2-2. The soil depression, where discolored soils show visual evidence of contamination, is approximately 200 ft by 200 ft. Contaminants of concern include TCE in the ground water and volatile organics and metals in the soil. Contaminated surface soils present a direct-contact threat.

The RI/FS will assess the threat posed by the site. FIT data are insufficient to determine the extent of contamination at the site. A phased approach will be used to first determine the boundaries of contaminated soil and ground water in Phase I and then to collect more extensive data through a well-directed investigation in Phase II. Phase I entails sampling of existing wells and soil gas to determine the boundaries of the ground water plume and sampling of surface soils to determine the areal extent of soil contamination. Phase II activities will include installation and testing of additional ground water wells and sampling of subsurface soils.

2.2 STAGE 2 - IDENTIFY DATA USES/NEEDS

Stage 2 activities entail defining the quality and quantity of data that will be required to meet the objectives set in Stage 1. Definition of specific uses for data and attendant data quality requirements lays the groundwork for a sound and efficient data collection program. Data are required for risk assessment, site characterization, evaluation of alternatives, and engineering design.

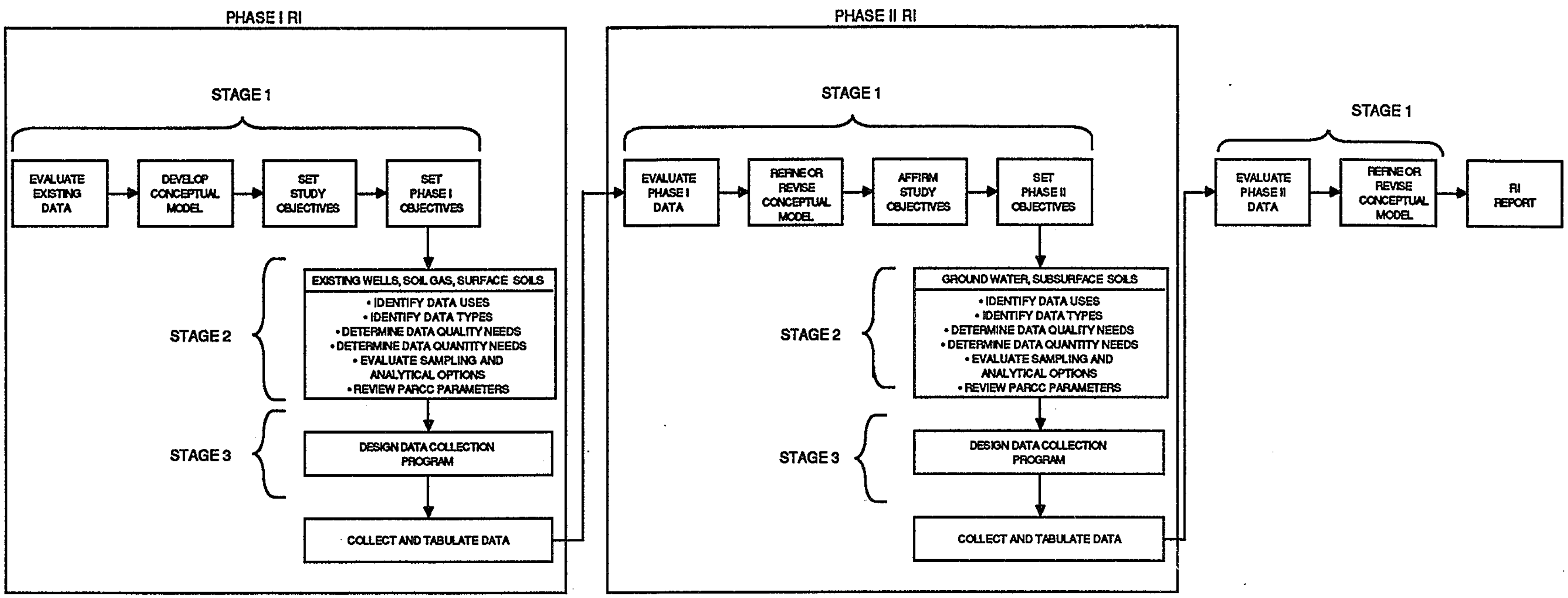


FIGURE 2-1
DQO PROCESS WITHIN PHASED WORK FLOW FOR EXAMPLE RI/FS

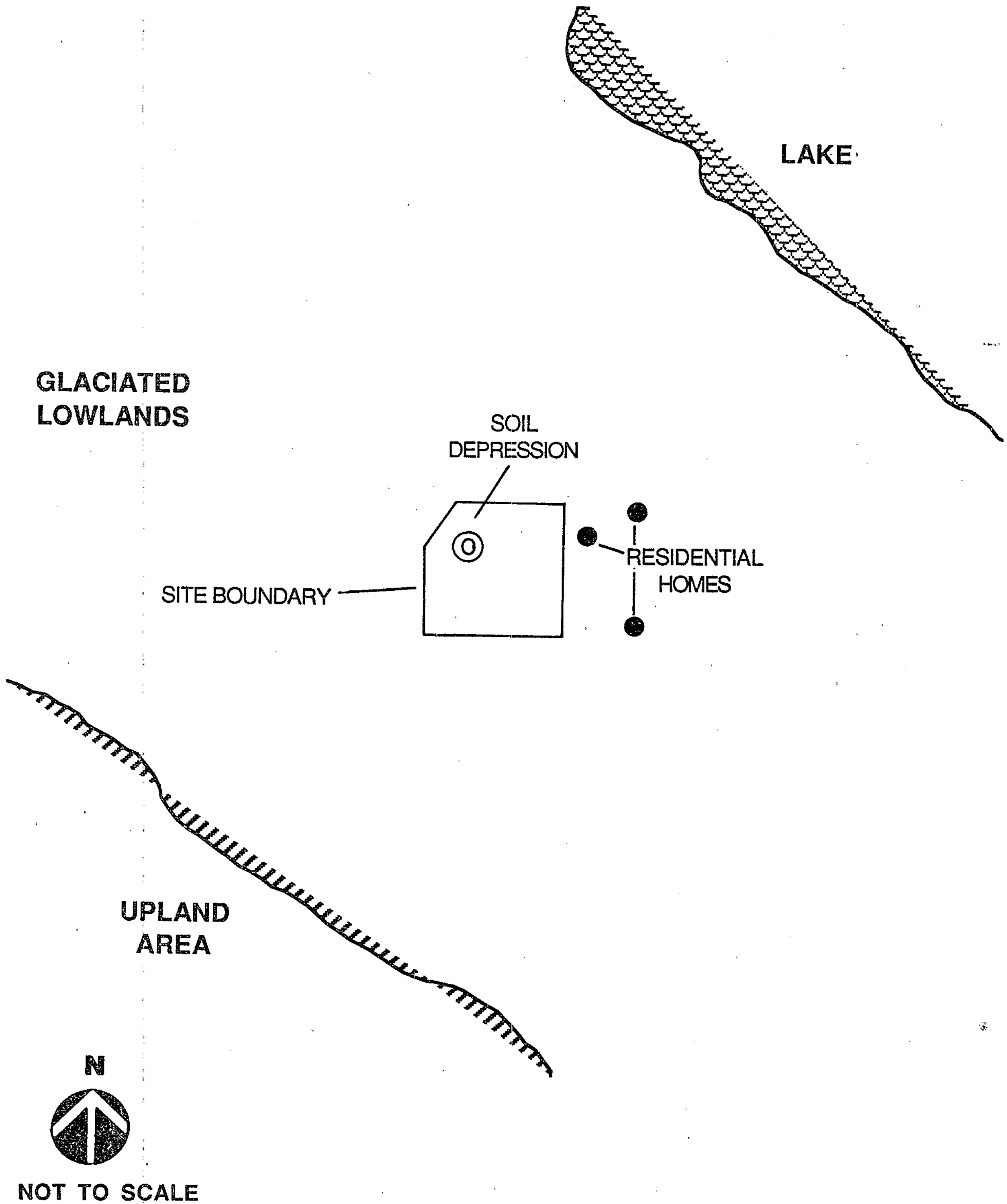


FIGURE 2-2
EXAMPLE SITE LOCATION MAP

Table 2-1 provides a summary of the results of Stage 2 activities for the example site. Detailed discussion of Stage 2 activities is included in the following sections:

- Section 4.0 - Overall RI/FS
- Section 5.1 - Phase I Ground Water
- Section 5.2 - Phase I Soil Gas
- Section 5.3 - Phase I Surface Soils
- Section 6.1 - Phase II Ground Water
- Section 6.2 - Phase II Subsurface Soils

2.3 STAGE 3 - DESIGN DATA COLLECTION PROGRAM

For Stage 3, a data collection program is designed to meet the requirements identified in Stage 2. Data collection activities must be designed for each media component of the phases. Tables 2-2 and 2-3 summarize plans for data collection activities. Stage 3 activities are discussed in detail in the following sections:

- Section 5.4 - Phase I
- Section 6.3 - Phase II

TABLE 2-1 DATA QUALITY SUMMARY

	PHASE I		
Activity	Sample Existing Wells	Soil Gas	Surface Soil
Objective	Samples from existing wells will be used to determine if contaminants are present in residential wells and to obtain information on the levels of contaminants in on-site monitoring wells.	Soil gas samples will be taken and analyzed to indicate the extent of volatile organics in the ground water.	Surface soil samples will be taken to assess the ingestion threat presented by lead, arsenic, and chromium. Samples will also be taken to measure the horizontal extent of contaminants.
Prioritized Data Use(s)	Risk assessment Site characterization	Site characterization Evaluation of alternatives	Risk assessment Evaluation of alternatives Engineering Design
Appropriate Analytical Levels	Risk Assess.: III, IV, V Site Charac.: I, II, III	Site Char.: II, III, IV Eval. Alt.: II, III, IV	Risk Assess.: III, IV, V Eval. Alt.: II, III, IV Eng. Design: II, III, IV
Contaminants of Concern	TCE, Arsenic, Chromium, Lead	TCE	Arsenic, chromium, lead
Level of Concern	5 ppb TCE/50 ppb metals	Not applicable	Arsenic - 25 - 35 mg/kg Lead - 450 - 550 mg/kg Chromium - 90 - 110 mg/kg
Required Detection Limit	2 ppb TCE	5-10 ppb	Low mg/kg range metals
Critical Samples	Residential wells	Two consecutive clean samples indicating the outer boundary of the plume	Clean samples at outer boundary of contaminated area

TABLE 2-1 DATA QUALITY SUMMARY
(continued)

PHASE II		
Activity	Ground Water	Subsurface Soils
Objective	Ground water data are required to evaluate the extent of contamination, develop a risk assessment, and assess potential remedial alternatives.	Soil samples will be taken and analyzed for VOAs and metals to determine the horizontal and vertical extent of contaminants, provide input to a risk analysis, and provide information necessary to evaluate remedial alternatives.
Prioritized Data (Use(s)	Risk assessment Evaluation of alternatives	Risk assessment Evaluation of alternatives Engineering Design
Appropriate Analytical Levels	Risk Assess: III, IV, V Eval. Alt.: II, III, IV	Risk Assess.: III, IV, V Eval. Alt.: II, III, IV Eng. Design: II, III, IV
Contaminants of Concern	TCE, arsenic, chromium, lead	TCE, arsenic, chromium, lead
Level of Concern	5 ppb TCE/50 ppb metals	4 - 40 mg/kg TCE Arsenic - 25 - 35 mg/kg Lead - 450 - 550 mg/kg Chromium - 90 - 110 mg/kg
Required Detection Limit	2 ppb TCE	2 mg/kg TCE Low mg/kg range metals
Critical Samples	Wells MW1 and MW2	Clean samples at boundaries of contaminated area

TABLE 2-2 DATA COLLECTION PLAN SUMMARY PHASE I

	PHASE I		
Activity	Sample Existing Wells	Soil Gas	Surface Soil
Staff Requirements	Field technicians Chemist	Field technicians Chemist	Field technicians Chemist
Data Types	VOA Metals	VOA	Metals
Sample Type	Grab	Soil gas	Grab
Number of Samples	3 private wells 2 on-site wells	49	89
QA/QC Samples	4 replicates (private) 4 matrix spike (private) 1 duplicate (on-site) 1 spike (on-site)	Not applicable	60 See Section 5.3.5 for detail
Background Samples	Well OW2	3 samples 0.5 mi south of depression	4 (minimum)
Sampling Procedures	Private wells sampled at tap; on-site wells sampled by bailer	Withdraw soil gas from a hand-dug hole; inject into detector	Obtain sample from 0-2 in. depth intervals

TABLE 2-2 DATA COLLECTION PLAN SUMMARY PHASE I
(continued)

	PHASE I		
Activity	Sample Existing Wells	Soil Gas	Surface Soil
Analytical Methods/Equip.			
Level I Field Screening	--	PID	--
Level II Field Analysis	--	Field GC with PID	X-ray fluorescence
Level III Non-CLP Laboratory Methods	GC/MS	--	AA, FAA, ICAP
Level IV CLP RAS Methods	EPA Method 624 (VOA) Metals RAS	--	Metals RAS
Level V Nonstandard Methods	Method 601/602 (VOA)	--	--

TABLE 2-3 DATA COLLECTION PLAN SUMMARY PHASE II

PHASE II		
Activity	Ground Water	Subsurface Soils
Staff Requirements	Hydrogeologist Drillers Chemist	Geologist Drillers Chemist
Data Types	pH Conductivity Basic water quality parameters Permeability Hydraulic head	VOA Metals
Sample Type	Grab	Grab
Number of Samples	5	72
QA/QC Samples	1 duplicate 1 spike	18 (replicates sent to CLP)
Background Samples	1 background well	2 per event
Sampling Procedures	Well installation SOPs	Standard split-spoon sampling procedures
Analytical Methods/Equip.		
Level I Field Screening	--	--
Level II Field Analysts	GC/PID - volatiles only	GC for volatiles X-met for metals
Level III Non-CLP Laboratory Methods	GC/MS, FAA, ICAP	GC/MS, AA, ICAP
Level IV CLP RAS Methods	VOA Metals RAS	RAS
Level V Nonstandard Methods	Method 601/602 (VOA)	

3

DQO STAGE 1
RI/FS
SCOPING PROCESS

IDENTIFY DECISION TYPES

IDENTIFY AND INVOLVE DATA USERS

EVALUATE AVAILABLE INFORMATION
DESCRIBE CURRENT SITUATION
REVIEW EXISTING DATA
ASSESS ADEQUACY OF DATA

DEVELOP CONCEPTUAL SITE MODEL
EVALUATION MODEL
COMPUTER MODEL

SPECIFY RI/FS OBJECTIVES

DETERMINE NEED FOR ADDITIONAL DATA

3.0 DQO STAGE 1 - RI/FS SCOPING PROCESS

3.1 IDENTIFY DECISION TYPES

Stage 1 of the DQO sequence is an inherent component of the RI/FS project scoping process and is shown in Figure 3-1. As shown in Figure 1-2, Stage 1 is initiated during the RI/FS scoping process.

As the DQO (and RI/FS) process continues, the scoping of the project will become focused. Stage 1 will be initiated whenever new data are evaluated or objectives/decisions must be redefined. Subsequent to the initial RI/FS scoping process (e.g., after the completion of Phase I), Stage 1 of the DQO sequence is abbreviated in scope, and is focused mostly on the evaluation of newly acquired data. In cases where the field investigations have revealed a situation requiring a redefinition of the objectives, the entire Stage 1 process may have to be repeated.

Stage 1 of the DQO process is undertaken to identify the decision makers and data users and to involve them in the process of identifying the data requirements and decision types which will have to be made during the RI/FS. This section outlines the process for performance of Stage 1 through an example situation. Detailed descriptions of the Stage 1 process are contained in the companion document, Data Quality Objectives For Remedial Response Activities - Development Process (Section 3.0).

For the example site, the data available from previous investigations performed by EPA's Field Investigation Team (FIT) contractor serve as the basis for scoping the RI/FS. The DQO process is initiated upon receipt of a work assignment which, in this case, will be undertaken as a federal-lead RI/FS.

3.2 IDENTIFY AND INVOLVE DATA USERS

The list of potential data users must be developed at the outset of the DQO process. The primary data users are those individuals involved in ongoing RI/FS activities. For this site, primary data users are the EPA Remedial Project Manager (RPM), and the contractor's site manager and staff. The site manager has the primary responsibility for incorporating DQOs into the planning and implementation activities. The RPM and the site manager will work in a parallel fashion and be continually involved with the technical staff through the course of the project.

The initial list of decision makers and data users that will be involved in the example site are as follows:

- Decision Maker:
    - EPA Remedial Project Manager (RPM)
- Primary Data User:
    - EPA RPM
    - Contractor site manager
    - Contractor personnel (hydrogeologist, analytical chemist, chemical engineer, water treatment engineer, and others)

Secondary data users include all individuals (or parties) that rely on RI/FS outputs to support their programmatic activities. Secondary data users provide input to the decision maker (and

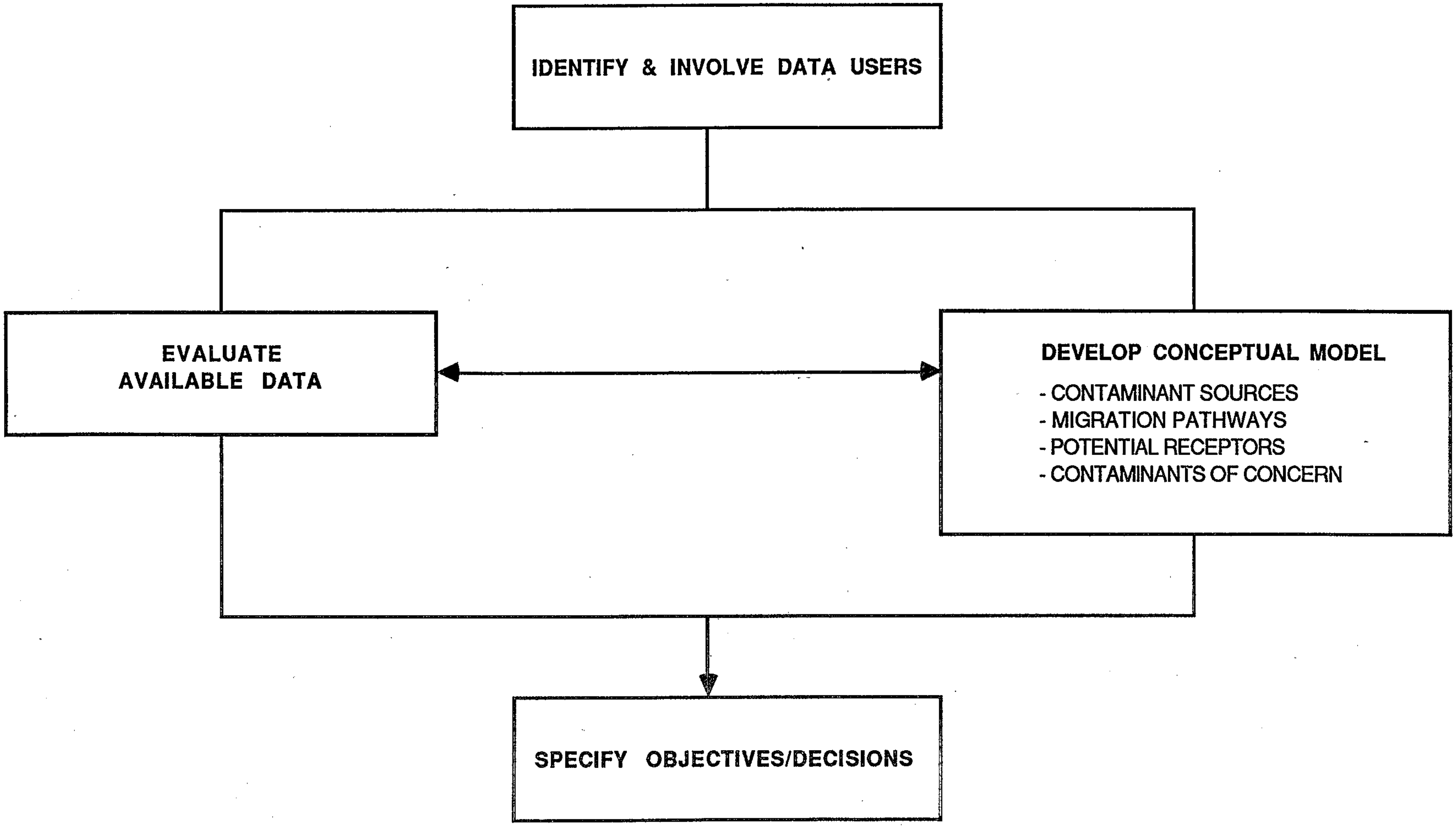


FIGURE 3-1
DQO STAGE 1 ELEMENTS

primary data users) during the DQO development process through generic data needs and, on occasion, site-specific data needs. Secondary data users that may be included in this example site are listed below:

- Secondary Data Users:
    - EPA Enforcement Personnel (PRP determination)
    - State Agency Personnel (remedy concurrence)
    - Agency for Toxic Substances and Disease Registry (ATSDR) (health assessment)
    - Corps of Engineers (RD/RA)

Other groups which may be involved in the RI/FS process include the following:

- Support group:
    - ESD personnel (QA integrity)
    - Office of Regional Counsel personnel (compliance with policy)
    - EPA HQ Personnel

Primary data users will attend an RI/FS scoping meeting which will include a review of available data and identification of data users' needs. Secondary data users are brought into the scoping process as necessary.

3.3 EVALUATE AVAILABLE INFORMATION

In this step of the DQO process, the existing information and available data for the example site are compiled and evaluated. In addition, a reconnaissance level site visit is performed by the site manager and appropriate staff to evaluate and confirm the available data, and thus develop an objective assessment of current site conditions.

3.3.1 DESCRIBE CURRENT SITUATION

The example site is located in a low-lying area with land forms created by glacial activities. A number of homes in the vicinity of the site obtain water supplies from an unconfined aquifer. A plan of the site showing the location of the residences and general site configuration is presented on Figure 3-2. The site has been used for disposal of hazardous wastes. During site reconnaissance discolored soils were noted within a depression measuring approximately 200 ft by 200 ft. Other areas of the site did not show any evidence of disturbance, and the vegetative ground cover outside the area of the depression did not display any sign of stress. Review of time-sequential aerial photographs and other information obtained from EPA and state files confirmed the depression as the only area of waste disposal. Based on interviews with witnesses, the depressed area has been the site of many disposal events. It appears that material was not disposed of in one particular location; rather, material was disposed of randomly throughout the depressed area. Based on this information, several highly contaminated zones are expected to be scattered throughout the depressed area. The site is presently unsecured and has unlimited access.

3.3.2 REVIEW EXISTING DATA

As part of the site investigation performed by the FIT contractor, a thorough field reconnaissance of the entire site was performed. A number of samples were obtained and submitted to the CLP for a full scale Hazardous Substance List and metals (HSL-1,2) analysis consisting of volatile and semi-volatile organics, base/neutral and acid extractables, PCB/pesticides and inorganics (metals).

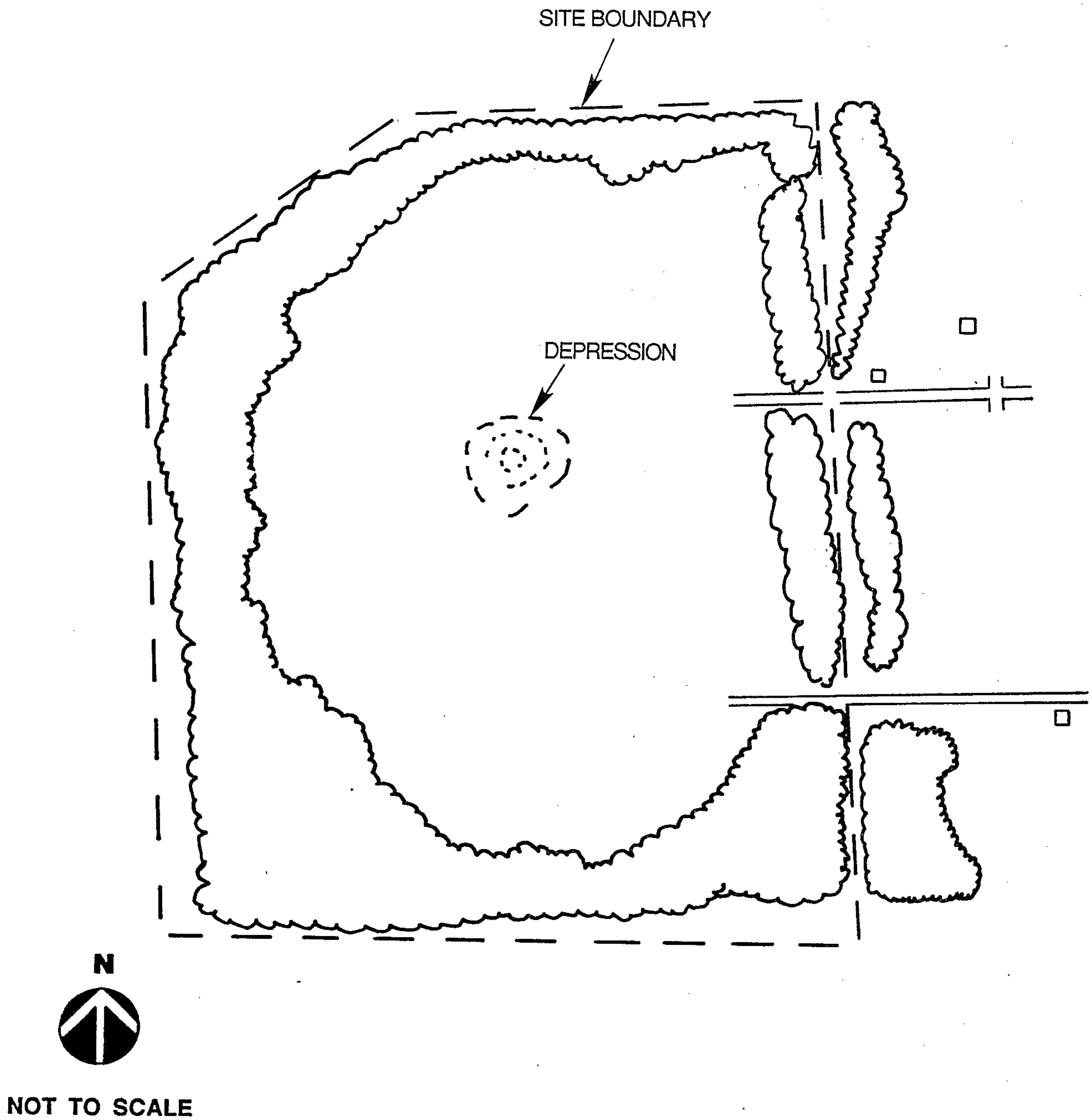


FIGURE 3-2
SITE PLAN

In addition, a photoionization detector (PID) was used to monitor the air for organic vapors over the entire site. Samples taken include three near surface (12 inches deep) soil samples taken from the discolored soil area; a ground water sample from each of two on-site monitoring wells; and three samples from off-site private wells. Contaminants of concern include TCE in ground water and volatile organics and metals in the soils. Figure 3-3 shows the FIT sampling locations and the site boundary.

The samples were analyzed by the CLP using RAS analytical methods and detection limits. Table 3-1 summarizes the data available for the example site. Soils contained metals and organics plus a high pH (about 10). PID screening did not indicate any above-background organic concentrations in the air with the exception of small (2 ppm) deflections inside the surface soil sample boreholes. The data are insufficient to characterize the site in terms of the degree and extent (both horizontal and vertical) of contamination and thus to support any potential remedial alternatives in the FS. Air and surface water have not been identified as potential sources or pathways for contaminant migration in the FIT investigation.

3.3.3 ASSESS ADEQUACY OF DATA

An essential step in the evaluation of available information is determining the reliability and acceptability of the available data. The data available for the example site were reviewed in terms of methods of collection and analytical techniques. The documentation of sample collection techniques is drawn from the site investigation report. Based on this review, the site manager concludes that the site data are both reliable and acceptable, but are insufficient to adequately characterize the site. Although no contamination was reported for the residential well samples, they were analyzed by CLP RAS methods which have a detection limit (5 ppb) equal to the drinking water level of concern for TCE and, therefore, the data may not be indicative of the actual health risks.

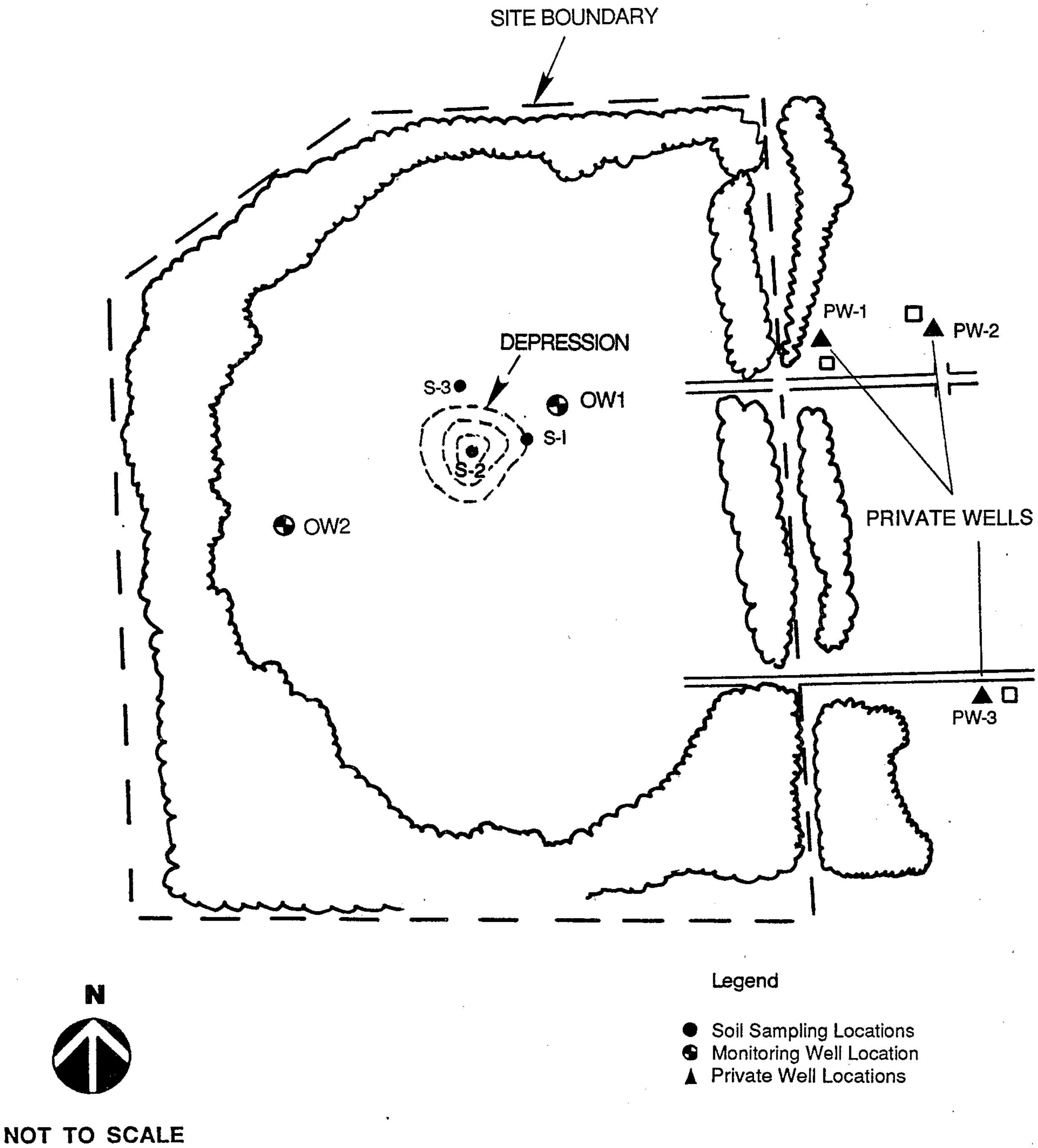
3.4 DEVELOP CONCEPTUAL SITE MODEL

Based on available information, a conceptual model is developed to provide an understanding of the sources of contaminants, the migration pathways of contaminants, and potential receptors. The conceptual model is presented schematically at the initial meeting of the data users. Conceptual models can include components from computer models, analytical models, graphic models, and/or other techniques. Conceptual models are discussed in Section 3.3 of the DQO Development Process document.

The conceptual model of the example site is presented in Figure 3-4. The conceptual model is relatively simplistic; however, if additional data collection activities identify any complex geologic features, these would be reflected in a more complex conceptual model. If necessary, a series of models could be developed by media to identify contaminant migration pathways.

Under day-to-day circumstances the potential for contaminant release into the atmosphere is considered minimal. A review of meteorological information obtained from a NOAA weather station southwest of the site has shown the winds to be predominantly towards the west, away from the residential areas. Since there have been no documented odor complaints and the only elevated organic vapor readings measured by the site inspection team were at the discolored soil area, the air contaminant pathway is not considered significant for either organics or metals (dusts).

More information is required concerning the potential threat from direct contact with -- and the potential ingestion of -- surface soils contaminated with lead, arsenic and chromium. The potential for direct contact with (or exposure to) organics is assessed to be low since organics (detected on site) tend to volatilize rapidly from surface soils: however, the potential for direct contact with on-site soils contaminated with metals must be evaluated.



Note: Distance from depression to private wells is approximately 1 mile.

FIGURE 3-3
FIT SITE INVESTIGATION SAMPLING LOCATIONS

TABLE 3-1

EXAMPLE SITE
FIT SITE INVESTIGATION DATA

	SOILS			MONITORING WELL		PRIVATE WELLS		
	S-1	S-2	S-3	OW1	OW2	PW-1	PW-2	PW-3
VOLATILE ORGANICS (ppb)								
Benzene	ND	5	ND	ND	ND	ND	ND	ND
Trichloroethene (TCE)	47	350	ND	52	ND	ND	ND	ND
Tetrachloroethene (PCE)	ND	23	ND	ND	ND	ND	ND	ND
Toluene	ND	12	ND	ND	ND	ND	ND	ND
Xylene	ND	10	ND	ND	ND	ND	ND	ND
METALS (ppm)								
Arsenic	ND	75	ND	ND	ND	ND	ND	ND
Chromium	ND	5,000	ND	ND	ND	ND	ND	ND
Lead	ND	1,000	ND	ND	ND	ND	ND	ND

NOTES: ND - Not detected
Base Neutrals, Acid Extractables and PCB/Pesticides were not detected in any sample.

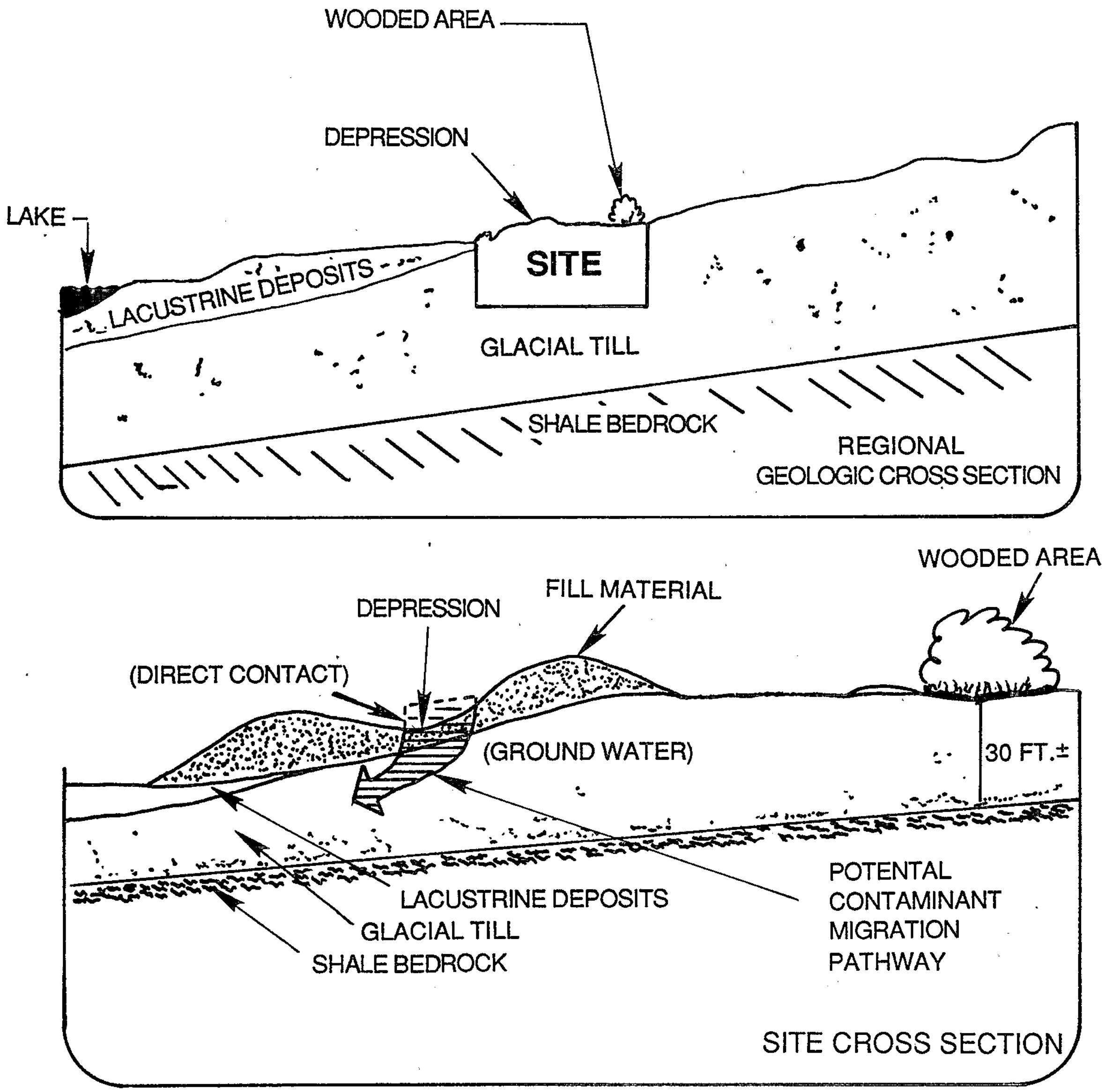


FIGURE 3-4
CONCEPTUAL SITE MODEL
(Looking South)

Surface runoff is not considered a complete contaminant pathway since the area of discolored soil is located within a depression and precipitation is low while infiltration is high. The low topography of the source area results in all runoff flowing into the soil depression.

The site is located in an area which has been influenced by glacial activities. The lake northeast of the site at one time covered much of the area. The fine sediments laid down during periods of glacial activity (lacustrine deposits) have low permeabilities and limit the rate at which water percolates and migrates in these materials. Directly beneath the site, however, glacial till deposits are encountered (as shown in Figure 3-4). These deposits are permeable and serve as a source of potable water for homes in the area. Shale bedrock underlies the entire region. The shale contains brackish ground water and is not a suitable source of potable water.

Regional ground water flow is towards the east. Water level measurements from the two on-site wells indicate that the hydraulic gradient within the shallow unconfined aquifer may cause ground water to move in an easterly direction; however, the exact direction of the hydraulic gradient is unknown until additional wells are installed. The depth to the water table averages 15 ft. There is no available information on the vertical hydraulic gradient. Private residences are located approximately 1 mile east of the discolored source area. Residents obtain drinking water from wells screened in the unconfined aquifer. No contamination has been found in these wells to date; however, the potential migration of contaminants to these wells poses a threat to human health.

The soils in the depression are known to contain elevated levels of heavy metals, specifically lead, arsenic and chromium. Based on the concentrations of metals detected during the FIT investigation, and the soil characteristics (i.e., pH of 10 which will keep the metals bound to the soils), the metals do not pose a major risk via the ground water pathway. The presence of volatile organics, however, does present problems since migration to water supplies may occur. The presence of the volatiles in the monitoring well (OW-1) on site indicates that they are in the ground water underlying the site and may migrate off site to the private water supply wells.

Based on the results of the FIT investigation, TCE (which occurs at the highest concentration of the organics) and the three metals will be considered contaminants of concern. Sampling during the initial phase of the RI will be used to confirm the presence of these contaminants and indicate if other potential contaminants are present.

The major pathway for migration of contaminants from the site is the unconfined glacial till located beneath the site. This glacial till also serves as the source for water supply wells (receptors) off site. A secondary exposure pathway is through direct contact with and ingestion of on-site soils.

The site-specific conceptual model identifies the following components:

- The contaminated soil area is a potential source of contaminants
- The unconfined aquifer is the primary contaminant pathway
- The private wells east of the site are potential receptors
- The surface soils present a potential direct-contact pathway

Because of the limited amount of data available for the example site, the site manager and RPM determined that a computer simulation model should not be developed at this time.

3.5 SPECIFY RI/FS OBJECTIVES

The objective of an RI/FS is to determine the nature and extent of the threat posed by the release or potential release of hazardous substances and to evaluate remedial alternatives to support Agency decisions on the remedial action for the site. Achieving this broad objective requires that several complicated and interrelated activities be performed, each having objectives, acceptable levels of uncertainty, and attendant data quality requirements. The expression of these objectives in clear precise statements is the first step toward development of a cost-effective program for collection of sufficient data for decision making.

In general, the objectives for this example site are the following:

- Determine the extent and concentration of soil and ground water contamination
- Determine if human receptors are at risk from the ingestion of contaminants
- Determine and evaluate feasible remedial alternatives

3.6 DETERMINE NEED FOR ADDITIONAL DATA

The available data for the example site has identified potential source materials on site, contaminant migration pathways, and potential receptors. The available data are not adequate to complete the RI/FS or to support an RI/FS decision regarding site remediation. Therefore, collection of additional data is warranted and Stage 2 of the DQO process should be initiated.

Based on the information obtained from EPA and state files, the results of the FIT investigations, and the conceptual model, the site manager and the RPM have decided that a phased approach will be used for the collection of additional data.

4

DQO STAGE 2 RI/FS DEVELOPMENT

DQO STAGE 2 - IDENTIFY DATA USES AND NEEDS: OVERALL RI/FS

REMEDIAL ALTERNATIVES

IDENTIFY DATA QUALITY / QUANTITY NEEDS

EVALUATE SAMPLING / ANALYSIS OPTIONS

REVIEW PARCC PARAMETERS

4.0 DQO STAGE 2 - RI/FS DEVELOPMENT

In Stage 1 for the example site, the basic decision making process for the RI/FS was identified. The need for additional data to support the RI/FS decision was identified. The conceptual model developed in Stage 1 will serve as the basis for completion of the Stage 2 elements for the example site. In Stage 2 of the DQO process, the information required for the example site will be identified, the data quality and quantity required to support the RI/FS will be specified, and appropriate sampling and analytical methods will be chosen.

Stage 2 is initially undertaken for the overall RI/FS. Once data uses and attendant data quality needs are established for the overall site, the process will be refined for the components of individual phases. At the completion of individual tasks, results are integrated into the conceptual model and data base for the entire site. In this manner, the iterative and interactive DQO process is incorporated in the RI/FS work flow.

The major DQO Stage 2 elements are identified in Figure 4-1. Although the elements shown on Figure 4-1 appear as discrete units, in practice they are part of an integrated thought process with a feedback loop operating to continuously refine each element.

4.1 DQO STAGE 2 - IDENTIFY DATA USES AND NEEDS: OVERALL RI/FS

Data developed during the RI will be used for:

- Risk assessment
- Site characterization
- Screening and evaluation of remedial alternatives
- Remedial design

Table 4-1 summarizes the overall RI/FS data uses and needs.

Discolored soils in the depressed portion of the site indicate areas of contamination. The organic contaminants in the soil are suspected to be leaching into the underlying unconfined aquifer. Thus, the contaminants in the soil may affect the private wells east of the site. In addition, high levels of metals have been detected in the soils of the depressed area.

The potential for direct contact with contaminated soils exists. The extent and magnitude of soil contamination and the potential risks associated with direct contact and ingestion must be addressed. To adequately assess the risk presented by the soils, the total area of contaminated soils must be determined. This value will be used in conjunction with the action level determined during the risk assessment to determine an appropriate remedial action for the site.

Ground water is the major pathway for migration of contaminants from the suspected sources to the receptors. Information on the movement and contaminant concentration of the ground water is therefore required.

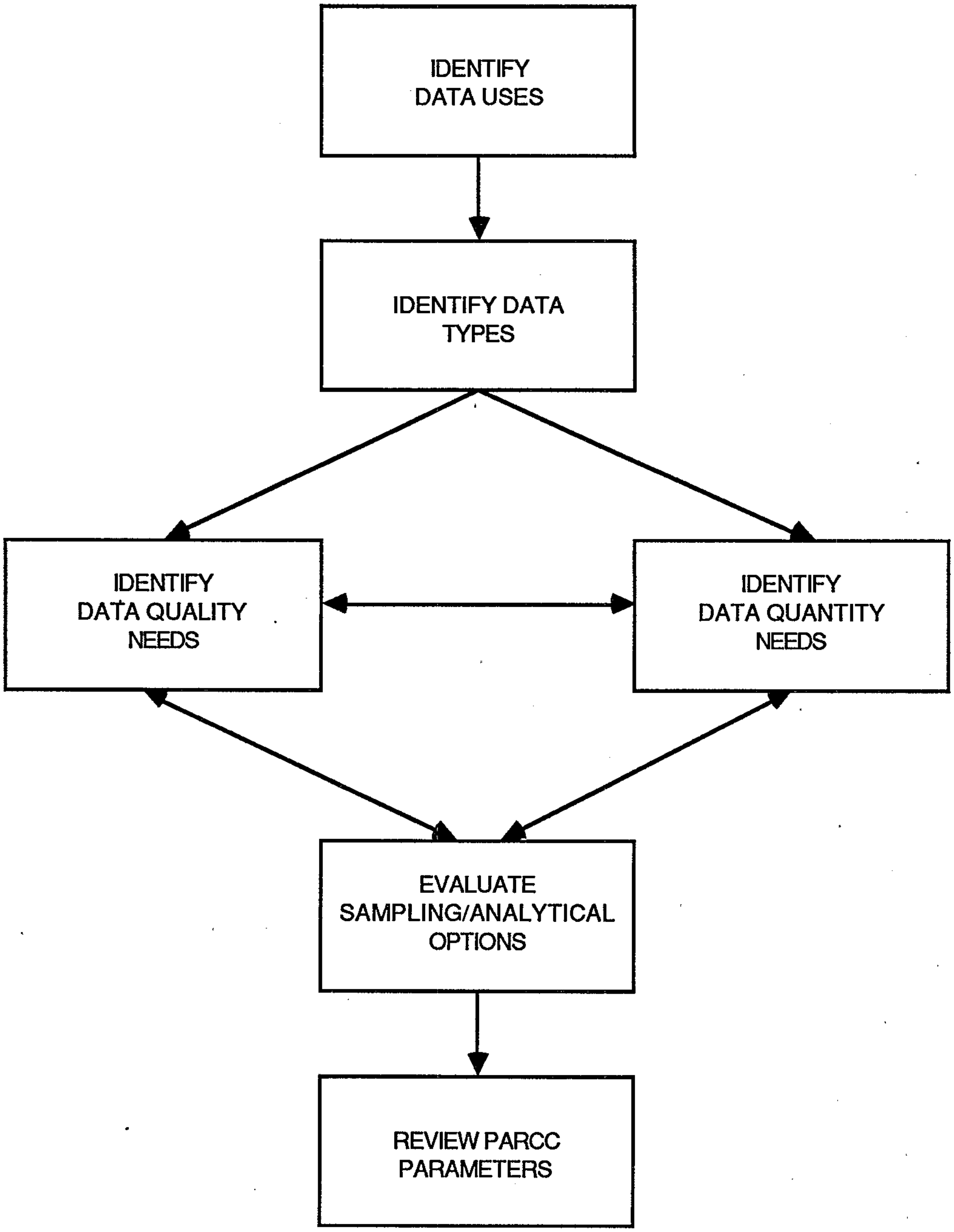


FIGURE 4-1
DQO STAGE 2 ELEMENTS

TABLE 4-1
DATA USES

SITE
NAME ____________________
LOCATION ____________________
NUMBER ____________________
PHASE ____________________
RI1 RI2 RI3 ERA FS RD RA

EPA REGION
____

DATE ____________________
CONTRACTOR ____________________
SITE MANAGER ____________________

DATA USE / MEDIA	SITE CHARACTERIZATION (INCLUDING HEALTH & SAFETY)	RISK ASSESSMENT	EVALUATION OF ALTERNATIVES	ENGINEERING DESIGN OF ALTERNATIVES	MONITORING DURING REMEDIAL ACTION	PRP DETERMINATION	OTHER ______
SOURCE SAMPLING TYPE ______							
SOIL SAMPLING							
GROUND WATER SAMPLING							
SURFACE WATER/SEDIMENT SAMPLING							
AIR SAMPLING							
BIOLOGICAL SAMPLING							
OTHER ______							

NOTE: CHECK APPROPRIATE BOX (ES)

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Consistent with the objectives of the RI/FS as defined in Stage 1, data required to address the overall RI/FS include:

- Data on the extent and magnitude of contaminants in the ground water and soils
- Data concerning the potential migration and timing of migration
- Data on the health and environmental risk of ingestion of contaminated ground water and soils
- Data on the physical constraints associated with ground water/soil extraction and treatment
- Data on the physical and chemical properties of ground water and soil
- Data related to any residual or sidestream disposal requirements associated with ground water treatment and on-site soil remediation or removal/treatment

4.2 REMEDIAL ALTERNATIVES

The following potential remedial alternatives will be evaluated for the ground water as part of the RI/FS:

- No action
- In situ treatment
- Hydraulic containment
- Physical containment
- Ground water extraction and treatment
- Alternate water supplies

For the ground water extraction option, a number of treated effluent discharge alternatives will be evaluated, including discharge to municipal sewer, deep well injection, or discharge to infiltration basins on site. If contaminants are found above levels of concern in drinking water wells, alternate water supplies may be provided as an expedited response.

In addition to the ground water pathway, the direct contact pathway for contaminated soils will be assessed. The potential remedial alternatives for the soils which will be evaluated as part of the RI/FS include:

- No action
- Excavation and on-site treatment
- Excavation and off-site treatment/disposal
- Cap (may also require a barrier such as a slurry wall)
- Enhanced volatilization
- Incineration

4.3 IDENTIFY DATA TYPES

Data types required for site evaluation, risk assessment, and evaluation of the remedial alternatives include both chemical and physical characteristics as well as the extent of contamination. Table 4-2 summarizes the data types required to assess remedial alternatives.

The physical properties of the aquifer are important in evaluation of remedial alternatives which involve ground water extraction or containment. The physical properties of the aquifer and the spatial data will be utilized in determining the volume of the contaminated plume. Parameters which influence the volume of contaminated ground water are the horizontal and vertical extent of contaminants (i.e., a three-dimensional outline of the contaminant plume) and the porosity of the aquifer. In any remedial action involving pumping, the volume of water removed is expected to be at least an order of magnitude greater than the volume marked by the boundaries of the plume. Effective porosity, grain size, and permeability data will also be obtained for the evaluation of enhanced volatilization procedures.

The water quality parameters and the contaminants analysis (VOA and metals) obtained from both the private and newly installed monitoring wells will be used to determine the extent of ground water contamination and to evaluate the applicability of various treatability options. Physical and chemical data (types) will also be obtained for soils, and are required for evaluating treatment and disposal options.

4.4 IDENTIFY DATA QUALITY/QUANTITY NEEDS

The various tasks and phases of this remedial investigation will require different levels of data quality/quantity. The data quality/quantity needs for each specific task/phase will be discussed in the following sections.

Data quality will be summarized for each medium within each phase in the following format:

Prioritized Data Uses

Appropriate Analytical Levels

Contaminants of Concern

Levels of Concern

Required Detection Limit

Critical Samples

The Development Process manual provides a thorough description of these parameters in Section 4.0. Although not always addressed quantitatively, precision and accuracy values for analytical methods are also used to assess data quality.

4.5 EVALUATE SAMPLING/ANALYSIS OPTIONS

Sampling and Analysis Components

There are several options available for investigating potential ground water and soils contamination at the site. The options are based on combinations of the following tasks:

TABLE 4-2
RI/FS DATA TYPES

DATA TYPES	GROUND WATER	SOILS
A) PHYSICAL PARAMETERS		
PERMEABILITY		✓
POROSITY		✓
HYDRAULIC HEAD	✓	
GRAIN SIZE		✓
STANDARD PENETRATION TEST		✓
PARTICLE SIZE DISTRIBUTION		✓
% ORGANIC CARBON		✓
BTU CONTENT		✓
B) WATER QUALITY PARAMETERS		
Fe	✓	
Mn	✓	
pH	✓	
TDS	✓	
TOC	✓	
COD	✓	
TOX	✓	
HARDNESS	✓	
ALKALINITY	✓	
ORGANIC COLOR	✓	
FILTERED METALS	✓	
UNFILTERED METALS	✓	
C) CONTAMINANTS		
VOLATILE ORGANICS	✓	✓
METALS	✓	✓
ORGANICS SCREENING		✓
METALS SCREENING		✓
D) SPATIAL DATA		
HORIZONTAL EXTENT	✓	✓
VERTICAL EXTENT	✓	✓

- Existing well sampling
- Soil gas sampling
- Soil sampling
- Installing and sampling monitoring wells

The two major types of contaminants of concern are volatile organics and metals. Existing wells in the vicinity of the site will be sampled to determine if contaminants are present. If contaminated, consideration must be given to implementation of an expedited response (i.e., supply an alternate source of water).

Soil gas sampling can assist in delineating the boundaries of the ground water plume. The soil gas evaluation will be conducted as a continuous field activity and completed prior to the installation of any monitoring wells.

Monitoring wells will be installed based on the results of the soil gas sampling program. These wells will be used to evaluate the extent of ground water contamination and will serve as an early warning system of contaminant migration towards the private wells.

To determine the range and extent of metals contamination, a surface soil sampling program will be initiated. Data obtained from this analysis will be used to determine the extent of contamination and to assist in determining the level of more detailed vertical and horizontal sampling.

Sampling and Analysis Approach

The RI at this example site is planned to proceed in a phased approach with the following tasks:

PHASE IA - Ground water sampling and analysis from the five existing wells (three residential and two on-site wells)

PHASE IB - Soil gas sampling and field screening for VOAs

PHASE IC - Surface soil sampling and field analyses for metals

PHASE IIA - Monitoring well installation with soil and ground water sampling and analysis

PHASE IIB - Subsurface soil sampling and analysis (may or may not be performed based on the results of Phase I investigations)

Resource Requirements

Performance of the field program will require, at a minimum, a drilling crew, a geologist, and an analytical chemist. The site manager must plan to have these personnel available throughout the soil sampling phase. Analytical equipment required includes a field GC, an X-ray fluorescense metals analyzer, and analytical support from the CLP and/or other established laboratories.

4.6 REVIEW PARCC PARAMETERS

The PARCC (precison, accuracy, representativeness, completeness and comparability) parameters are overall indicators of data quality and are defined in Section 4.0 of the Development Process manual. As with data quality and quantity, the PARCC parameters are specified at the phase and task level and are not specified for the overall RI/FS. Furthermore, PARCC parameters, specifically precision and accuracy (where they are available), are compound, media, and method-specific.

The historical precision and accuracy achieved by different analytical techniques will be reviewed for each task to allow a comparison of the analytical techniques. In addition, representativeness, completeness and comparability will also be reviewed and addressed.

5

DQO DEVELOPMENT PHASE I REMEDIAL INVESTIGATIONS

5.0 DQO DEVELOPMENT PHASE I REMEDIAL INVESTIGATIONS

5.1 DQO STAGE 2 - IDENTIFY DATA USES AND NEEDS: RI PHASE IA - SAMPLING EXISTING WELLS

5.1.1 IDENTIFY DATA USES: RI PHASE IA - SAMPLING OF EXISTING WELLS

Residents living in the immediate vicinity of the site currently obtain potable water from the unconfined aquifer. Analysis of ground water samples obtained from three private wells sampled during the FIT site investigation indicated that no contamination was present in the private water supply wells. However, organics were detected in the on-site monitoring well, and the conceptual model for the site indicates that a potential route of migration of contaminants is through the soil to the private wells tapping the surficial aquifer. In addition, while metals were not detected in any of the wells, their presence in the soil samples indicates they should be a concern. While the FIT samples were analyzed for the full scale Hazardous Substance List and metals (HSL-1,2), only one sample (S-2) showed significant contamination, with only organics and metals detected. To determine if the private wells are contaminated, samples will be obtained from each of the three homes located immediately east of the site. In addition, the on-site monitoring wells will be sampled to confirm the results of the FIT sampling. As such, samples will be analyzed for the full scale HSL-1,2 compounds. However for the sake of brevity, the DQO process will only be carried through for organics and metals as described in the remainder of Section 5.0.

High quality samples from the private wells are critical because the risk of making a wrong decision concerning continued use of the water supply has significant public health implications.

The data needs for RI Phase IA have been identified as information concerning the presence or absence and concentration of contaminants in the drinking water wells of nearby residents. This information will be used to perform a risk assessment by comparing the existing concentration to established action levels or standards.

Data Use Categories

Ground water is the major pathway for migration of contaminants from the suspected source to the receptors. Information about the movement and contaminant concentration of the ground water (at the identified receptor) is therefore required.

As shown on Tables 5-1 and 5-2, data obtained from Phase IA ground water investigations will be used to determine the presence and concentration of organics and metals contaminants in the three private and two on-site monitoring wells. This information can then be used to perform a risk analysis to determine if a health risk exists due to ingestion of ground water.

5.1.2 IDENTIFY DATA TYPES: RI PHASE IA - SAMPLING OF EXISTING WELLS

The data type required to evaluate the potential hazards associated with the ingestion of (potentially) contaminated ground water is the presence and concentration of contaminants (i.e. VOAs and metals).

TABLE 5-1
DATA USES

SITE
NAME ____________________
LOCATION ____________________
NUMBER ____________________
PHASE ____________________
RI1 RI2 RI3 ERA FS RD RA

EPA REGION
____

DATE ____________________
CONTRACTOR ____________________
SITE MANAGER ____________________

DATA USE / MEDIA	SITE CHARACTERIZATION (INCLUDING HEALTH & SAFETY)	RISK ASSESSMENT	EVALUATION OF ALTERNATIVES	ENGINEERING DESIGN OF ALTERNATIVES	MONITORING DURING REMEDIAL ACTION	PRP DETERMINATION	OTHER ________
SOURCE SAMPLING TYPE ________							
SOIL SAMPLING							
GROUND WATER SAMPLING							
SURFACE WATER/SEDIMENT SAMPLING							
AIR SAMPLING							
BIOLOGICAL SAMPLING							
OTHER ________							

NOTE: CHECK APPROPRIATE BOX (ES)

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TABLE 5-2
DQO SUMMARY FORM

1. SITE

NAME DQO DEMONSTRATION
LOCATION ______
NUMBER ______

EPA REGION ______
PHASE ______
RI 1 RI 2 RI 3 ERA FS RD RA
(CIRCLE ONE)

2. MEDIA *(CIRCLE ONE)*

SOIL	GW	SW/SED	AIR	BIO	OTHER

3. USE *(CIRCLE ALL THAT APPLY)*

SITE CHARAC. (H&S)	RISK ASSESS.	EVAL. ALTS.	ENGG DESIGN	PRP DETER.	MONITORING REMEDIAL ACTION	OTHER

4. OBJECTIVE EXISTING WELLS WILL BE SAMPLED TO DETERMINE IF CONTAMINANTS ARE PRESENT IN RESIDENTIAL WELLS AND TO OBTAIN INFORMATION ON THE LEVELS OF CONTAMINANTS IN ON-SITE OBSERVATION WELLS

5. SITE INFORMATION

AREA 200ft X 200ft DEPRESSION DEPTH TO GROUND WATER 15 feet
GROUND WATER USE DRINKING WATER
SOIL TYPES GLACIAL TILL - DEPTH 0-30 ft; SHALE 30 - >100 ft
SENSITIVE RECEPTORS ______

6. DATA TYPES *(CIRCLE APPROPRIATE DATA TYPES)*

A. ANALYTICAL DATA

pH	PESTICIDES	TOX
CONDUCTIVITY	PCB	TOC
VOA	METALS	BTX
ABN	CYANIDE	COD
TCLP	______	______

B. PHYSICAL DATA

PERMEABILITY	HYDRAULIC HEAD
POROSITY	PENETRATION TEST
GRAIN SIZE	HARDNESS
BULK DENSITY	______
______	______

7. SAMPLING METHOD *(CIRCLE METHOD(S) TO BE USED)*

ENVIRONMENTAL BIASED GRAB NON-INTRUSIVE PHASED
SOURCE GRID COMPOSITE INTRUSIVE ______

8. ANALYTICAL LEVELS *(INDICATE LEVEL(S) AND EQUIPMENT & METHODS)*

LEVEL 1 FIELD SCREENING - EQUIPMENT ______
LEVEL 2 FIELD ANALYSIS - EQUIPMENT ______
LEVEL 3 NON-CLP LABORATORY - METHODS ______
LEVEL 4 CLP/RAS - METHODS METALS FOR ALL SAMPLES, VOAs WELLS OW1, OW2
LEVEL NS NON STANDARD METHOD 601/602 - VOAs PRIVATE WELLS

9. SAMPLING PROCEDURES

BACKGROUND - 2 PER EVENT OR WELL OW1 & OW2
CRITICAL (LIST) 3 PRIVATE WELL SAMPLES (A1, A2 & A3)
PROCEDURES PRIVATE WELLS - SAMPLE AT TAP, OW1 & OW2 BAILER

10. QUALITY CONTROL SAMPLES *(CONFIRM OR SET STANDARD)*

A. FIELD
COLLOCATED - 5% OR 4 DUPLICATES
REPLICATE - 5% OR ______
FIELD BLANK - 5% OR 1
TRIP BLANK - 1 PER DAY OR 1

B. LABORATORY
REAGENT BLANK - 1 PER ANALYSIS BATCH OR ______
REPLICATE - 1 PER ANALYSIS BATCH OR ______
MATRIX SPIKE - 1 PER ANALYSIS BATCH OR ______
OTHER ______

11. BUDGET REQUIREMENTS

BUDGET $16,000 SCHEDULE 2 DAYS FOR SAMPLING, 5 DAYS FOR CHEMIST
STAFF 2 PERSON FIELD CREW, CHEMIST FOR DATA VALIDATION & INTERPRETATION

CONTRACTOR ______ PRIME CONTRACTOR ______
SITE MANAGER ______ DATE ______

FOR DETAILS SEE SAMPLING & ANALYSIS PLAN CDM SF DQO 1.002

5.1.3 IDENTIFY DATA QUALITY NEEDS: RI PHASE IA - SAMPLING EXISTING WELLS

Primary Data Quality Factors

Prioritized Data Uses:	Risk Assessment Site Characterization
Appropriate Analytical Levels:	Risk Assessment: III, IV, V Site Characterization: I, II, III
Primary Contaminant of Concern:	TCE
Level of Concern:	5 ppb TCE/50 ppb Lead, Chromium, Arsenic
Required Detection Level:	2 ppb TCE
Critical Samples:	Residential Wells

The private wells were sampled during the FIT investigation and analyzed using CLP RAS procedures. CLP RAS methods have a detection limit of 5 ppb for most volatile organic analytes (see Appendix B). However, the level of concern associated with TCE in drinking water is 5 ppb, which is equal to the CLP RAS detection limit. Since analytical procedures perform poorly near their detection limits, CLP RAS methods will not be acceptable for samples obtained from the private wells. CLP SAS methods with lower detection limits will be used.

The 5 ppb level of concern for TCE has been obtained from the proposed drinking water standard under the Safe Drinking Water Act as (proposed) maximum contaminant levels (MCLs). MCLs represent the allowable lifetime exposure to the contaminant of concern for a 70 kg adult who is assumed to ingest two liters of water per day.

For this phase of the RI, the three private wells are considered critical data points.

5.1.4 IDENTIFY DATA QUANTITY NEEDS: RI PHASE IA - SAMPLING OF EXISTING WELLS

The existing on-site wells and the three private wells east of the site will be sampled once during Phase IA. The locations of these wells are shown in Figure 5-1.

5.1.5 EVALUATE SAMPLING/ANALYSIS OPTIONS: RI PHASE IA - SAMPLING EXISTING WELLS

Sampling and Analysis Components

The three residential wells in the vicinity of the site and the two on-site monitoring wells will be sampled as part of the Phase I investigation. If the three residential wells are contaminated, consideration must be given to implementation of an expedited response (i.e., supply an alternate source of water).

Sampling and Analysis Approach

Water from the private wells will be sampled directly from the tap, after allowing the water to run for at least 5 minutes. Samples will be taken from the tap because there is no other access to these wells. Any filtration or aeration devices will be removed or bypassed before sampling. Samples from the on-site monitoring wells will be obtained with dedicated (stainless steel) bailers. A minimum of 3-5 well volumes of water will be evacuated from the wells prior to obtaining samples.

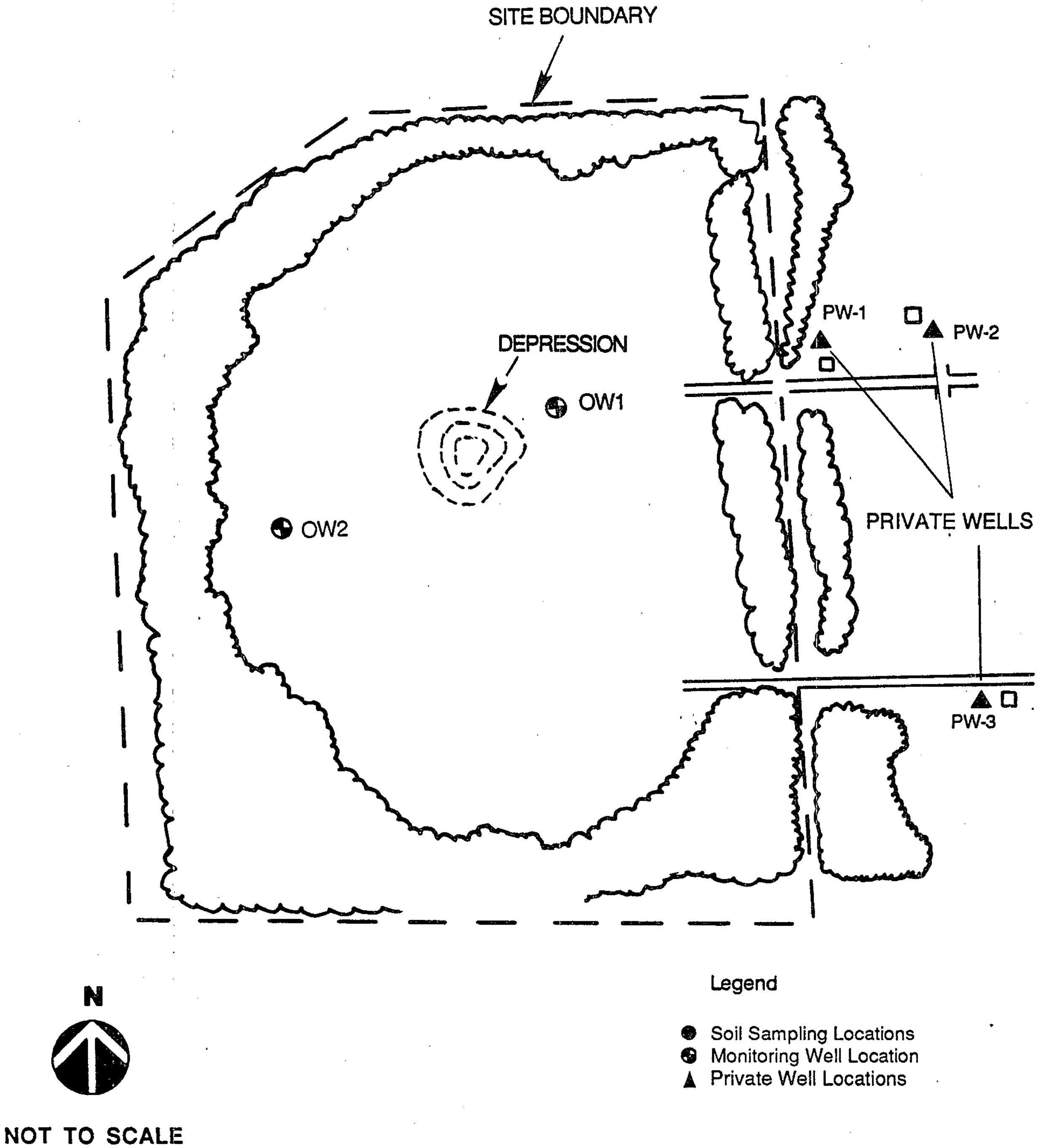


FIGURE 5-1
RESIDENTIAL AND ON-SITE WELL LOCATIONS

The sample from the on-site monitoring wells (OW1 and OW2) will be analyzed for volatile organics via method 624 because the associated detection limit of 5 ppb is sufficient and turnaround time is not an issue for these samples.

The analytical method chosen for analyzing the samples from the residential wells is method 601/602. This method has a detection limit of less than 1 ppb for the volatile compounds of concern. Method 601/602 can be obtained through the CLP via the special analytical services (SAS) feature or through a non-CLP laboratory.

Since residents are currently drinking well water, laboratory results are required within a short turnaround time. If the water is contaminated, an alternate water supply may be necessary. For these reasons, the IFB for the analyses of private well samples was issued with a turnaround time requirement of two-weeks. A CLP laboratory was located where it could meet the provisions of this IFB under an SAS request. Samples from the private wells will therefore be sent to this laboratory.

While the FIT sampling program did not identify detectable concentrations of metals in any of the well samples, the presence of lead, chromium and arsenic in the soils justifies testing of all wells for metals using CLP RAS methods.

The CLP RAS Contract Required Detection Limit (CRDL) of 5 ug/l, 10 ug/l and 10 ug/l (for lead, chromium and arsenic) are deemed sufficient for these analyses based on the MCL values of 50 ug/l for the three metals.

5.1.6 REVIEW PARCC PARAMETERS: RI PHASE IA - SAMPLING OF EXISTING WELLS

Because two analytical methods will be used for the ground water samples, two statements of the PARCC goals are required.

Precision - Well OW1 and OW2 Samples

The samples obtained from OW1 and OW2 will be analyzed using CLP RAS methods.

The historical precision of CLP RAS analytical methods for the contaminants found in soil sample S-2 (see Table 3-1) is shown below. These historical values are known from blind performance evaluation samples (see Appendix A) and are presented in percent relative standard deviation (%RSD). The method of calculating %RSD is shown in Appendix A.

Contaminant	Precision (% RSD)
TCE	17
PCE	13
Benzene	12
Toluene	14
Lead	32
Arsenic	9.4
Chromium	9.8

The methods by which these values were calculated are shown in Appendix A. Precision indicates the average percent error likely in a replicate measurement. A numerical example demonstrating the use of these precision values is given in Section 6.4.1. QC samples will be examined to determine the precision which is actually achieved.

Accuracy - Well OW1 and OW2 Samples

The samples obtained from OW1 and OW2 will be analyzed for metals and volatile organics using CLP RAS methods. The accuracy of these methods is known from blind evaluation sample data (see Appendix A). The historical accuracy of the selected methods for the contaminants found in the FIT investigations is shown below:

Contaminant	Accuracy (% Bias)
TCE	-22.8
PCE	-42.5
Benzene	-3.3
Toluene	-23.3
Lead	-0.7
Chromium	-2.6
Arsenic	-8.3

Accuracy, as expressed in percent bias, indicates the systematic error in an analytical method. Negative values indicate underestimation while positive values indicate overestimation. The values reported for TCE, for example, will be on average 22.8 percent less than the actual values.

QC samples will be analyzed to determine the actual accuracy achieved.

Representativeness - Three to five well volumes will be purged before sampling the observation wells to ensure that standing water is removed from the wells and that the samples are representative of ground water quality.

Completeness - The historical completeness achieved for CLP RAS analyses is 80-85 percent. This completeness range is acceptable because the observation well samples are not critical samples.

Comparability - The use of standard, published sampling and analytical methods plus the use of the QC samples described above will ensure data of known quality. This data set can then be compared with any other data of known quality.

Precision - Private Well Samples

The precision of method 601/602 is unknown and must be estimated. At the outset the final precision of the method is unknown; however, sufficient QC samples will be collected to determine precision.

Precision will be measured from replicate samples. The following formula will be used for precision as defined by relative percent difference (RPD):

$$RPD = \frac{2\left|X_1 - X_2\right| \times 100}{X_1 + X_2}$$

where X_1 is the concentration of replicate #1
X_2 is the concentration of replicate #2

$$RPD = \sqrt{2}\ RSD$$

Determining precision from a single pair of replicate samples is very inaccurate. To improve the efficiency of determining precision, more than one pair of replicate samples should be taken and the precision measures should be averaged. As the number of replicate samples increases, the certainty in the estimated precision measure increases. Since no information on the analytical method is available, it is impossible to state the precision of the method before the samples are analyzed. Although the certainty in the precision of the method cannot be stated ahead of time, it is known from basic statistics that as the number of measurements (n) increases, the uncertainty surrounding the average of the measurements decreases as 1/n. Given this relationship between uncertainty and the number of replicate samples, the reduction in uncertainty obtained from an additional replicate sample can be determined.

Number of Replicates	Reduction in Uncertainty
2	50%
3	34%
4	24%
5	20%
6	17%

The preceding table indicates that for more than four replicates there are diminishing returns in the reduction in uncertainty. For this reason it is cost effective to analyze four replicate samples.

To obtain four replicate samples from the three private wells, one well will be sampled in triplicate while the remaining two wells will be sampled in duplicate.

Accuracy - Private Well Samples

The private well samples will be analyzed via method 601/602. Performance evaluation sample data is unavailable for this method so the accuracy of the method is unknown. To estimate the accuracy of the method, spiked samples must be analyzed by the laboratory.

A spiked sample (as discussed in Appendix B of the guidance manual) contains a known amount of an analyte. If the laboratory method consistently overestimates or underestimates the concentration of spiked samples, the method contains a systematic error or, in statistical terms, the method is biased. The accuracy of the method is a measure of this bias.

A measure of the accuracy (% bias) of the method is given by:

$$\text{Accuracy} = \frac{R-S}{S} \times 100\%$$

where S is the known concentration, and

R is the value reported by the lab.

For this definition of accuracy, as the absolute value of the accuracy measure approaches zero, accuracy increases.

To efficiently determine accuracy, several spiked samples must be submitted for analyses. The accuracy measure will be calculated on each of the spikes, and the average of the accuracy measures from each of the spikes will be used as the accuracy of the method. As shown in the section on precision when an

average is used as an estimator, diminishing returns in uncertainty occur after four data points. For this reason four spikes will be required to efficiently determine accuracy.
Ideally, samples would be spiked in the field. However, field spiking is very difficult, so the spiking procedure will be performed in the laboratory. Spiking should be performed so that the spiked concentration is 5 ppb. This spiked value is specified so that the accuracy of the method can be estimated near the level of concern.

Representativeness - Private Well Samples

To ensure that samples are representative of the water consumed by the residents, samples will be taken from kitchen taps. Taps will be run for 5 minutes or until three well volumes have been removed prior to sampling so that the sample is representative of the overall quality of the well. During sampling the tap flow rate will be reduced so that the potential for volatilization is reduced. Also, any filtration or aeration devices will be bypassed or removed prior to sampling.

Completeness - Private Well Samples

Because these samples are critical, validated analyses must be obtained from each of the private wells. If validated analyses are not obtained from any of the three wells, an analytical chemist will be consulted immediately to determine why validated analyses were not obtained. Based on consultations with the chemist the analytical method will be modified or an alternative method will be suggested and the wells will be resampled.

Comparability - Private Well Samples

The use of standard sampling, analytical and quality control procedures and the QC samples described above will ensure known data quality and therefore comparability of the results with other data of known quality.

5.2 DQO STAGE 2 - IDENTIFY DATA USES AND NEEDS: RI PHASE IB - SOIL GAS INVESTIGATIONS

5.2.1 IDENTIFY DATA USES: RI PHASE IB SOIL GAS INVESTIGATIONS

To determine the approximate extent of the ground water plume and soil gas concentrations, soil gas sampling and analysis will be performed. The soil gas evaluation will aid in the selection of ground water monitoring well locations. These wells will be installed in Phase II of the RI based on the results of soil gas sampling.

Data Use Categories

Site characterization is the major data use category for information derived from this phase. A minor secondary data use category is engineering screening of alternatives.

5.2.2 IDENTIFY DATA TYPES: RI PHASE IB - SOIL GAS INVESTIGATIONS

Data types required to estimate the extent and concentration ranges of the contaminated ground water plume, (and to a lesser extent to allow engineering evaluation of alternatives) include the chemical analysis of the soil gas. This analysis will in turn reflect the volatile organic constituents and concentrations present in the soil and ground water (plume). Soil gas analyses will be conducted for benzene, TCE, PCE and 1,2 trans dichloroethane (DCE). DCE is a degradation product of TCE.

5.2.3 IDENTIFY DATA QUALITY NEEDS: RI PHASE IB - SOIL GAS INVESTIGATIONS

Data Quality Factors

Prioritized Data Uses:	Site Characterization Evaluation of Alternatives
Appropriate Analytical Level:	Site Characterization: I, II, III Evaluation of Alternatives: II, III, IV
Contaminants of Concern:	TCE
Level of Concern:	Not applicable
Required Detection Limit:	5 to 10 ppb
Critical Samples:	Two consecutive clean (i.e., representative of background conditions) samples indicating the outer boundary of plume.

Soil gas sampling and analysis results will indicate volatile organic concentrations in the soil pore spaces in the vadose (unsaturated) zone. Since health effects associated with the ingestion of contaminated ground water can occur when organics are in the low ppb range (see Section 5.1.3), analysis of soil gases will be required with a detection limit in the low ppb range.

Critical data points for the soil gas sampling task are the samples taken at the outer boundary of the plume (as defined by two consecutive clean samples), since these samples will define the extent of contamination.

5.2.4 IDENTIFY DATA QUANTITY NEEDS: RI PHASE IB - SOIL GAS INVESTIGATIONS

Factors

Soil gas samples will be obtained in the field at the locations identified in Figure 5-2. Sampling will begin at the suspected source and continue in a direction moving away from the source. Thus, the primary factor influencing the number of soil gas samples taken is the areal extent of the soil gas plume. Since the extent of the plume is unknown at this time, it is impossible to predict the number of required soil gas samples.

Number of Samples

Soil gas samples will be taken on a regular grid to maximize the representativeness of the samples. A sampling grid will be used to provide coverage over the entire 200-ft-by-200-ft discolored area. A number of important factors are considered in determining the grid spacing and hence the number of samples. These factors include the technical objectives, schedule, costs, the size of the site, and the conceptual model.

The grid size will be chosen based on these factors and the goals of the soil gas sampling task. The soil gas plume is related to the extent of the ground water plume. It is known from the FIT team sampling that TCE is present in the ground water at approximately 50 ug/l near well OW1. Based on the vapor pressure of TCE and the detection limits of the proposed analytical methods, the detectable soil gas plume will extend beyond well OW1. Well OW1 is approximately 300 ft from the center of the depressed area, so the soil gas plume is expected to extend a minimum of 300 ft east of well OW1.

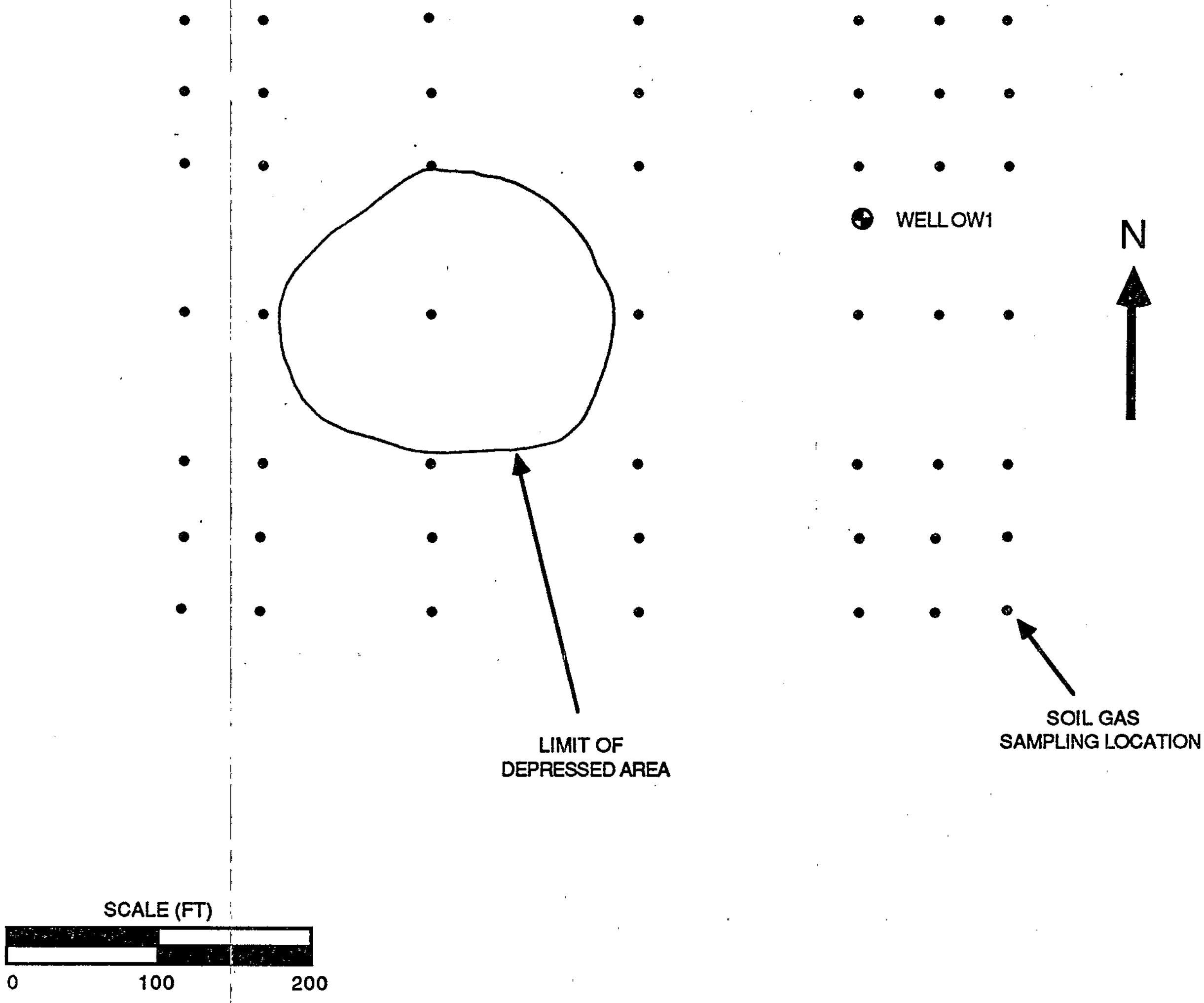


FIGURE 5-2
INITIAL SOIL-GAS SAMPLING GRID

The previous analysis provides a guide for determining a grid size. East of the depressed area soil gas contamination is likely to be found; therefore, only a coarse grid is required between the depressed area and well OW1. East of well OW1 a tighter grid is necessary to accurately determine the extent of the soil gas plume. Between the center of the depressed area and well OW1, a grid with 150-ft spacing in the east-west direction is required. This spacing will provide several samples within the depressed area which can be used to confirm the type and concentration of contaminants found in the soil-gas plume. East of well OW1 a 50-ft grid will be used. This grid size provides a maximum error of 50 ft in the determination of the soil gas plume. This error is deemed acceptable for this study.

North, south, and west of the depressed area, the extent of ground water contamination is unknown, so specific site information cannot be used to set the grid size. It is assumed that soil-gas contamination will be found beneath the depressed area, hence it is not necessary to sample soil gas in the depressed area. Beyond the depressed area, a 50-ft grid will be used to provide definition of the plume boundary. The initial soil gas grid is shown in Figure 5-2.

To determine the maximum soil gas plume extent, samples will be taken following the established grid space system and extending outwards at 50-ft intervals until two consecutive clean samples are obtained. For purposes of the Phase IB investigations, two clean samples will define the extent of contamination.

In addition to the locations listed above, three samples (not shown on Figure 5-2) will be taken 1/2 mile south of the discolored area to determine background soil gas conditions. Additional sample locations will be determined based on the results obtained at these initial locations.

5.2.5 EVALUATE SAMPLING/ANALYSIS OPTIONS: RI PHASE IB - SOIL GAS INVESTIGATIONS

Sampling and Analysis Approach

Two readily available analytical methods for volatile organic determination are suggested: an HNu 101, which is a photoionization detector (PID); and an HNu 301, which is a field gas chromatograph (GC). Each method has advantages and disadvantages. The HNu 101 is a hand-held, direct read-out, field instrument calibrated to detect benzene in the high ppb to low ppm range. Results are qualitative and provide a determination of total organic volatiles. The HNu 101 cannot be used to distinguish between individual organic fractions. Analyses are, however, easy to obtain on a real-time basis.

The HNu 301 is a field GC and combines the capabilities of a (PID) and a GC. This unit can provide a qualitative and quantitive measure of the contaminants present, with a detection limit of appoximately 5 ppb (for benzene). The HNu 301 utilizes the PID to "detect" organic compounds and the GC to separate the individual organic fractions. A trained operator is required to accurately operate the GC. Based on the overall objectives of the Phase IB effort, a quantitative evaluation of the contaminants is required. In order to characterize the composition of the soil gas plume, a GC will be used to analyze all soil gas samples.

This system will provide Level II analytical support. Prior to use of the GC in the field, appropriate columns, detectors, temperatures, and flow rates will be selected to ensure adequate component separation. Standard curves will be prepared for the soil gas in an analytical laboratory prior to initiating field work. The curves will be developed by spiking known quantities of the target volatile compounds in non-contaminated background samples representative of the physical nature of the soil on-site. The spiked samples will be run to develop volatile gas concentration chromatograms.

At each sampling point, a soil bucket auger will be used to excavate to a depth of 2 ft. A polyethylene pipe will be used as a sample probe and placed into the auger hole. The pipe will be connected to a portable air sampling pump by means of tygon tubing. The pump will be used to purge gases from the soil at a rate of 2 liters-per-minute for a period of 5 minutes to allow for equilibration of soil and tubing gas concentrations. The sample (5 ml) will then be withdrawn from the sample probe by syringe and injected into the GC. The amount of sample injected, column temperature, sample location, identification number, and point of injection will be recorded on the strip chart. The GC will be allowed to run long enough for the complete sample to elute from the system. Soil gas sampling will continue until the extent of the contaminant plume has been determined.

The DQO process for this phase is summarized in Table 5-3.

5.2.6 REVIEW PARCC PARAMETERS: RI PHASE IB - SOIL GAS INVESTIGATIONS

Level II analysis of the contaminants of concern using a field GC has been selected. Almost no historical data on the precision and accuracy achieved by this analytical technique exist. Fortunately, the numerical precision and accuracy of each measurement are not a serious concern for this site characterization effort since the analyses will be used solely to determine the presence or absence of contaminants.

Precision - No specific requirement.

Accuracy - No specific requirement.

Note: Since the objectives of Phase IB do not require that quantitative information be obtained, no specific QA/QC samples will be analyzed to determine precision and accuracy. However, the field GC will be calibrated daily to known standards to ensure proper instrument operation.

Representativeness - A sampling grid has been designed to obtain a representative picture of the soil gas plume.

Completeness - Completeness of 100 percent will be achieved for the critical samples i.e., the two consecutive clean samples at each edge of the plume. This will be accomplished by analyzing any clean samples in duplicate.

Comparability - The use of standard operating procedures should ensure comparability of the results.

5.3 DQO STAGE 2 - IDENTIFY DATA USES AND NEEDS: RI PHASE IC - SURFACE SOIL INVESTIGATION

5.3.1 IDENTIFY DATA USES: RI PHASE IC - SURFACE SOIL INVESTIGATIONS

Analytical results from the FIT investigations indicated that the soils were contaminated with heavy metals (sludges) -- specifically lead, chromium and arsenic. Because the site is not secure, nearby residents (especially children) could have direct contact with these soils. The most important exposure route is through direct ingestion of soils.

Data from this sampling phase will be used to determine the expected and likely worst-case exposures from ingestion of the surface soils in the depressed area. The exposures can be input to a simple exposure assessment model to determine the magnitude of the direct contact threat.

The data from this phase will also be used to determine the lateral extent of surface soil contamination. This information will be used to design a subsurface soil sampling program (if required based on Phase I information). Ultimately the information gathered in this phase will be combined with the subsurface information if gathered in a later phase to determine the total volume of soils contaminated by heavy metals.

TABLE 5-3
DQO SUMMARY FORM

1. SITE

NAME DQO DEMONSTRATION
LOCATION ______
NUMBER ______

EPA REGION ______

PHASE ______
RI 1 RI 2 RI 3 ERA FS RD RA
(CIRCLE ONE)

2. MEDIA *(CIRCLE ONE)*

SOIL	GW	SW/SED	AIR	BIO	OTHER SOIL GAS

3. USE *(CIRCLE ALL THAT APPLY)*

SITE CHARAC. (H&S)	RISK ASSESS.	EVAL. ALTS.	ENG'G DESIGN	PRP DETER.	MONITORING REMEDIAL ACTION	OTHER ______

4. OBJECTIVE SOIL GAS SAMPLES WILL BE TAKEN AND ANALYZED TO INDICATE THE EXTENT OF VOLATILE ORGANICS IN THE GROUND WATER

5. SITE INFORMATION

AREA 200 ft X 200 ft DEPRESSION DEPTH TO GROUND WATER 15 feet
GROUND WATER USE DRINKING WATER
SOIL TYPES GLACIAL TILL - DEPTH 0-30 ft; SHALE - DEPTH 30->100 ft
SENSITIVE RECEPTORS RESIDENTS LIVING 1 MILE EAST OF THE SITE

6. DATA TYPES *(CIRCLE APPROPRIATE DATA TYPES)*

A. ANALYTICAL DATA

pH	PESTICIDES	TOX
CONDUCTIVITY	PCB	TOC
VOA	METALS	BTX
ABN	CYANIDE	COD
TCLP	______	______

B. PHYSICAL DATA

PERMEABILITY	HYDRAULIC HEAD
POROSITY	PENETRATION TEST
GRAIN SIZE	HARDNESS
BULK DENSITY	______
______	______

7. SAMPLING METHOD *(CIRCLE METHOD(S) TO BE USED)*

ENVIRONMENTAL	BIASED	GRAB	NON-INTRUSIVE	PHASED
SOURCE	GRID	COMPOSITE	INTRUSIVE	______

8. ANALYTICAL LEVELS *(INDICATE LEVEL(S) AND EQUIPMENT & METHODS)*

LEVEL 1 FIELD SCREENING - EQUIPMENT ______
LEVEL 2 FIELD ANALYSIS - EQUIPMENT FIELD GC - CALIBRATED FOR 4 VOAs
LEVEL 3 NON-CLP LABORATORY - METHODS ______
LEVEL 4 CLP/RAS - METHODS ______
LEVEL NS NON STANDARD ______

9. SAMPLING PROCEDURES

BACKGROUND - 2 PER EVENT OR 3 SAMPLES 1/2 MILE SOUTH OF DEPRESSION
CRITICAL (LIST) 2 CLEAN SAMPLES INDICATING PLUME BOUNDARY
PROCEDURES WITHDRAW SOIL-GAS FROM A HAND DUG HOLE

10. QUALITY CONTROL SAMPLES *(CONFIRM OR SET STANDARD)*

A. FIELD
COLLOCATED - 5% OR ______
REPLICATE - 5% OR ______
FIELD BLANK - 5% OR NA
TRIP BLANK - 1 PER DAY OR NA

B. LABORATORY
REAGENT BLANK - 1 PER ANALYSIS BATCH OR NA
REPLICATE - 1 PER ANALYSIS BATCH OR NA
MATRIX SPIKE - 1 PER ANALYSIS BATCH OR NA
OTHER DAILY CALIBRATED SAMPLES

11. BUDGET REQUIREMENTS

BUDGET $9,750 SCHEDULE 2 WEEKS FOR SAMPLING & INTERPRETATION
STAFF 3 PERSON FIELD TEAM - TWO SAMPLERS, 1 CHEMIST WITH ONE PERSON DOUBLING AS HEALTH & SAFETY COORDINATOR

CONTRACTOR ______ **PRIME CONTRACTOR** ______
SITE MANAGER ______ **DATE** ______

FOR DETAILS SEE SAMPLING & ANALYSIS PLAN

CDM SF DQO 1.002

5.3.2 IDENTIFY DATA TYPES: RI PHASE IC - SURFACE SOIL INVESTIGATIONS

In this phase, surface contamination is the prime focus; therefore, only contaminants which are stable near the surface are of interest. Since the previous analyses failed to detect pesticides or other non-volatile contaminants, only heavy metals will be considered. As discussed in the conceptual model (Section 3.4.1) organic contaminants are not a source of concern for direct contact exposure as they tend to volatilize or migrate downward rapidly from surface soils.

To assess the magnitude of the potential threat associated with direct ingestion of (metals) contaminated soils, surface soil samples will be collected within the depressed area and analyzed for heavy metal concentrations--specifically arsenic, lead, and chromium since only these three metals were detected during previous FIT sampling.

5.3.3 IDENTIFY DATA QUALITY NEEDS: RI PHASE IC - SURFACE SOIL INVESTIGATIONS

<u>Data Quality Factors</u>

Prioritized Data Uses:	Risk Assessment Evaluation of Alternatives Engineering Design
Appropriate Analytical Levels:	Risk Assessment: III, IV, V Evaluation of Alternatives: II, III, IV Engineering Design: II, III, IV
Contaminants of Concern:	As, Cr, Pb
Levels of Concern:	As - 25 to 35 mg/kg Pb - 450 to 550 mg/kg Cr - 90 to 110 mg/kg
Required Detection Limits:	Given the high cleanup levels anticipated, detection limits in the low mg/kg range will be acceptable.
Critical Samples:	Clean samples at outer boundary of contaminated area.

The levels of concern shown above are typical of those used at past sites. These values are based on the health effects associated with ingestion of contaminated soil. Since the metal contaminants at this site are not expected to migrate to the ground water, ingestion is the only major route of exposure. Thus, the cleanup levels shown are representative of the actual cleanup level which will be determined after the data have been collected and an exposure assessment has been performed.

To assess the direct contact threat posed by soils contaminated by heavy metals, quantitative information on the concentrations of metals present must be obtained.

5.3.4 IDENTIFY DATA QUANTITY NEEDS: RI PHASE IC - SURFACE SOIL INVESTIGATIONS

To provide a representative and unbiased measure of the surface metals concentrations within the depressed area, samples will be taken from the depth interval 0-2 in. The depth interval 0-2 in. is chosen because a child is most likely to ingest soil from this interval. Samples will be located on a regular two-dimensional grid. As discussed in Appendix C of the Development Process manual, sampling on a regular grid will provide representative samples and will minimize bias. The grid size is directly related to the number of samples so the grid size must be based on the acceptable uncertainty in the results, the spatial variability of the contaminants, and the cost of acquiring and analyzing a sample.

The spatial variability of contaminants is a measurement of how contaminants vary as a function of location. If contaminant concentrations vary radically over short distances, spatial variability is high. If contaminant concentrations do not vary radically throughout the site, spatial variability is low. When spatial variability is high, unexpectedly large concentrations of contaminants can occur in regions where contaminant levels are otherwise low. In areas with high spatial variability, a large number of samples are required to ensure, with reasonable confidence, that the majority of the highly contaminated zones are sampled. If the grid spacing is sufficiently small to adequately measure the spatial variability of the contaminants, it will also be sufficient to determine the uncertainty in the results.

The depressed area has been the site of many disposal events. Based on interviews with witnesses to the disposal it appears that material was dumped not in one particular location, but randomly throughout the depressed area. Based on this information, several highly contaminated zones are expected to be scattered throughout the depressed area. In other terms, the spatial variability of the contaminants is expected to be high. This information indicates that a tight grid will be required to assess the spatial variability and the risk.

To determine an adequate grid size a meeting was held between contractor and EPA personnel. The various expected properties of the contaminants were discussed. Major topics were the spatial variability of the contaminants, the threat posed by the contaminants, and the cost of obtaining the samples. Because spatial variability is expected to be high, a large number of samples were planned. The grid spacing was chosen based on perceived threat. It was determined that the largest highly contaminated area which would be acceptable to miss was 100 sq ft. Based on this assessment a 10-ft grid was chosen (see Appendix A of the Development Process manual). This grid spacing yields a total of approximately 400 samples over the 200-ft-by-200-ft depressed area.

Based on the conceptual model and the assumed threat, a large number (400) of samples have been proposed to assess surface soil contamination. The large number of proposed samples is based on an assumed conceptual model. If the conceptual model is incorrect and contaminants are actually found in large continuous zones, far fewer than 400 samples will be required. To validate the conceptual model, surface soil data will be evaluated after approximately 90 samples have been collected and analyzed.

To assess the validity of the existing conceptual model, data must be collected on a tight grid (10 ft); however, at this point there is no justification for sampling the entire depressed area at this density. One method for assessing the validity of the conceptual model without sampling the entire site on a 10-ft grid is to sample on a hybrid grid. The hybrid grid consists of 25 samples located on a 50-ft grid and 64 samples located on a 10-ft grid. The 64 closely spaced samples are split into 16 groups of 4 samples. One group of four is then located at the center of each of the 50-ft cells defined by the data located on the 50-ft grid. The hybrid grid is shown in Figure 5-3.

The two components of the hybrid grid will provide different information concerning the spatial variability of the contaminants. The samples from the 50-ft grid will provide information over the entire depressed area. This information will be used to determine the mean concentration of surface contaminants within the depressed area and to assess the variability (correlation) of the data at large distances. The samples from the 10-ft grid will be used to assess the validity of the conceptual model and to determine the variability of the data at short distances.

Based on the evaluation of this initial data set, the conceptual model might be revised. This revised conceptual model will be used in determining additional data requirements.

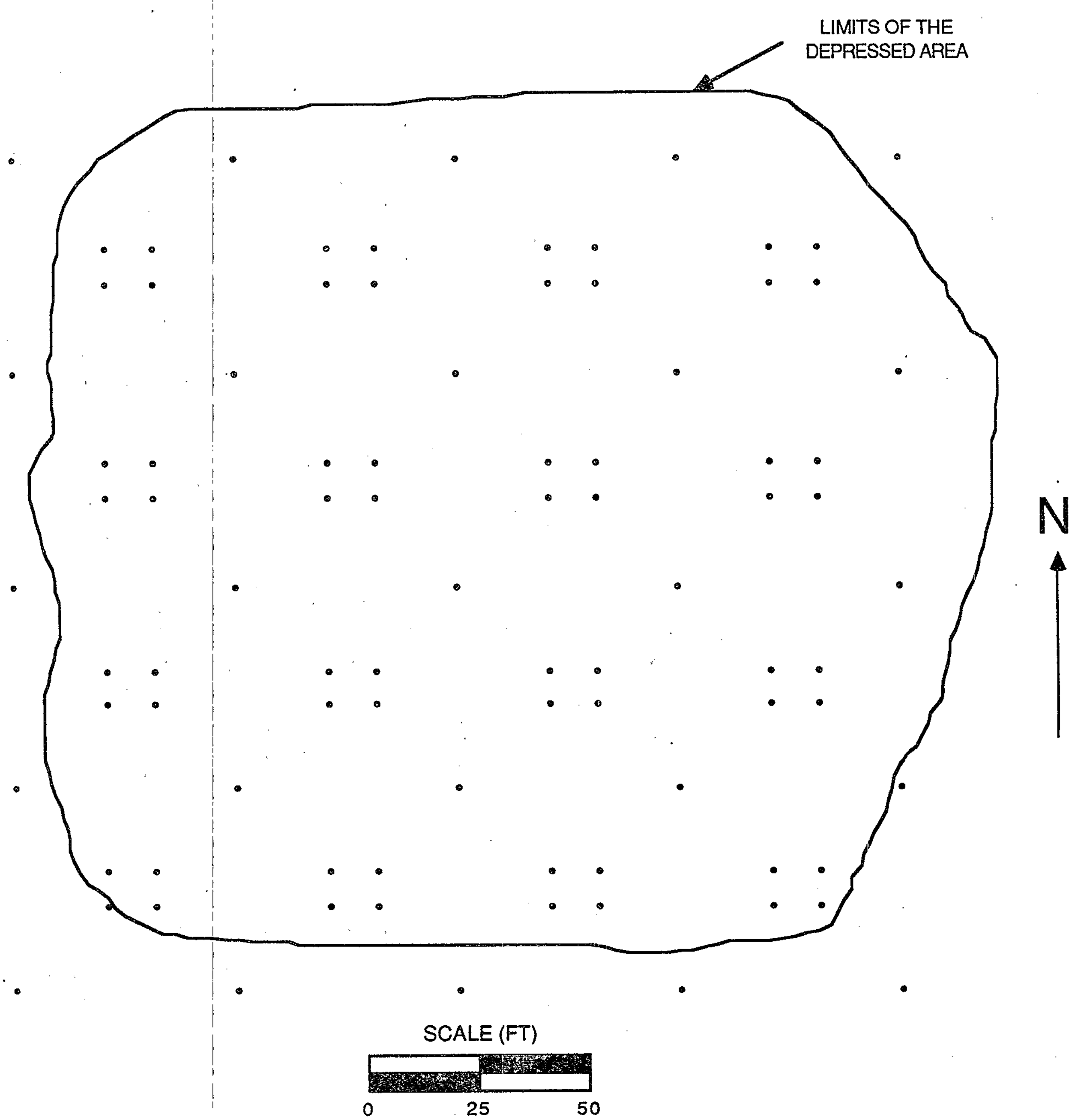


FIGURE 5-3
HYBRID GRID FOR SAMPLING THE DEPRESSED AREA
(89 DATA TOTAL)

As part of the data analysis the uncertainty surrounding the estimate of the mean contaminant concentration within the depressed area will be determined. Determining this uncertainty requires knowledge of the spatial variability of the data as a function of distance (see Appendix A Development Process manual). To model spatial variability, data separated by small and large distances are required; thus, the hybrid grid is ideal for determining spatial variability as a function of distance.

5.3.5 EVALUATE SAMPLING/ANALYSIS OPTIONS: RI PHASE IC - SURFACE SOIL INVESTIGATIONS

Analysis options include CLP, local laboratory, and on-site analysis. Each type of analyses has certain properties which are presented below.

Analytical Method	Turnaround Time	Cost per Sample	Relative Accuracy And Precision
CLP/RAS	6 weeks [a]	\$60[b]	High
Local Lab/SAS[e]	2-7 days	\$80[c]	High
On-Site Analysis	2-24 hours	\$ 8[d]	Unknown

a. Time includes data validation.
b. Cost is for paperwork and shipping only. No lab cost is included.
c. Atomic absorption, acid digestion analysis cost. Includes paperwork cost.
d. Cost is for sample preparation and analysis labor only.
e. Costs for SAS are similar to b above.

Because future phases of this study depend on the results of this phase, the turnaround time of an analytical method is a critical issue. If the CLP is used to analyze these samples. project delays may be unavoidable. Both the local lab and on-site analysis provide adequate turnaround times, however, on-site analysis is 10 times less expensive than the local lab. Thus, on-site analysis would allow 10 times more samples to be analyzed at the same cost as local lab analysis.

Based on known site history and the conceptual model (see Section 5.3.4) a large number of samples will be required to characterize the extent of contamination. The only available analytical method which can be used to analyze a large number of samples for an acceptable cost is on-site analysis. The on-site analysis method of choice is X-ray fluorescence using a Columbia Scientific X-Met 840 (X-Met) or similar instrument.

Ordinarily on-site (Level II) analysis would not be suitable for risk assessment uses. However, in this case, a rigorous field calibration procedure with off-site laboratory verification of the calibration standards will be used. Also, a large number of QC samples will be analyzed to estimate precision and accuracy. The resulting data will be statistically reviewed and. if the field data are judged unreliable, the soil samples will be sent to an off-site laboratory for analysis. The use of these procedures makes this field analysis more like a Level III analysis and, therefore, suitable for risk assessment uses.

Experience with the X-Met at previous sites indicates that the detection limit of the X-Met ranges from 2 to 200 mg/kg. Based on these values the X-Met might not provide adequate detection limits; however, consultations with experts on the method indicate that there is high likelihood that the X-Met will provide detection limits less than 20 mg/kg. To allow for the possibility that the detection limits of the X-Met will be above the action levels, 8 ounces of soil will be retained from each sample. The retained soil will be sent to a local laboratory if unacceptably high X-Met detection limits are found.

Because the accuracy and precision of this instrument are unknown, sufficient QC samples must be analyzed to assess accuracy and precision. The procedure for assessing the accuracy and precision of the X-Met and the number of QC samples required are discussed below.

The X-Met will be calibrated using the lead, arsenic, and chromium concentrations from four on-site surficial soil samples. The four calibration samples will be taken along a radial line stretching from the center to the edge of the discolored area as shown in Figure 5-4. The four calibration samples will be equally spaced along this line to ensure that these samples span the range of metal concentrations occurring within the discolored area. The actual metal concentrations will be determined by laboratory analyses.

The four calibration samples will contain 40 ounces of soil each. The soil will be homogenized and then split into seven samples. Two of the splits will be sent to the CLP, four of the splits will be sent to a local lab and the remaining sample will be retained. The method of splitting the calibration samples is shown in Figure 5-5. The rationale for this replicate analysis procedure is presented below.

Sixteen samples (four replicates of each of the four calibration samples) will be sent to a local lab with an in-place QA/QC program. The results for these samples will be obtained within 1 week of submission to the lab. The concentration values for each set of four replicate samples will be averaged to obtain the estimated concentration of each calibration sample. The X-Met will then be calibrated using these four average values.

The average value of four replicate samples is used to calibrate the X-Met because there will be high confidence in the average of these four values. The exact degree of confidence is unknown until the data values are obtained. It is known however, that uncertainty surrounding the average of four replicate measurements is four times less than the uncertainty surrounding a single measurement. This four times reduction in uncertainty is deemed acceptable for this study by the site manager with approval by the RPM.

After the X-Met is calibrated using the four calibration samples, analysis of actual samples can proceed. During analysis of actual samples, each of the four calibration samples must be run daily using the X-Met. Each calibration sample must be run a minimum of 15 times during this RI phase to estimate the distribution of errors for each calibration sample. Calibration samples will be analyzed at various times during the day to assess any temporal variability in the measurements. A minimum of 15 samples has been chosen because work at previous sites has shown that the X-Met can produce unreliable results. The reliability of the X-Met will be assessed by examining the distribution of the errors for each of the calibration samples. If these error distributions are symmetric and well behaved, the X-Met will be termed reliable and the accuracy and precision of the procedure will be defined. If however, the distribution of errors are highly skewed or otherwise ill behaved, the X-Met will be considered unreliable and the numerical values given by the X-Met cannot be used. In the event that the X-Met is judged unreliable, soil samples will be sent to a local lab with an in-place QA/QC program. For this reason, the sample size must be at least 8 oz. and the soil must be labeled and stored until the X-Met's validity is determined.

Once 15 QC samples have been run for each calibration sample, the uncertainty surrounding X-Met readings will be known as a function of concentration. Given the relationship between concentration and certainty, the uncertainty surrounding any reported value can be stated.

To ensure that the X-Met has been properly calibrated, two replicates of each of the four calibration samples will be sent to the CLP for RAS metals analysis. Only two replicates are sent to the CLP because the CLP RAS method has known accuracy and precision (see Appendix A). These two replicate samples will

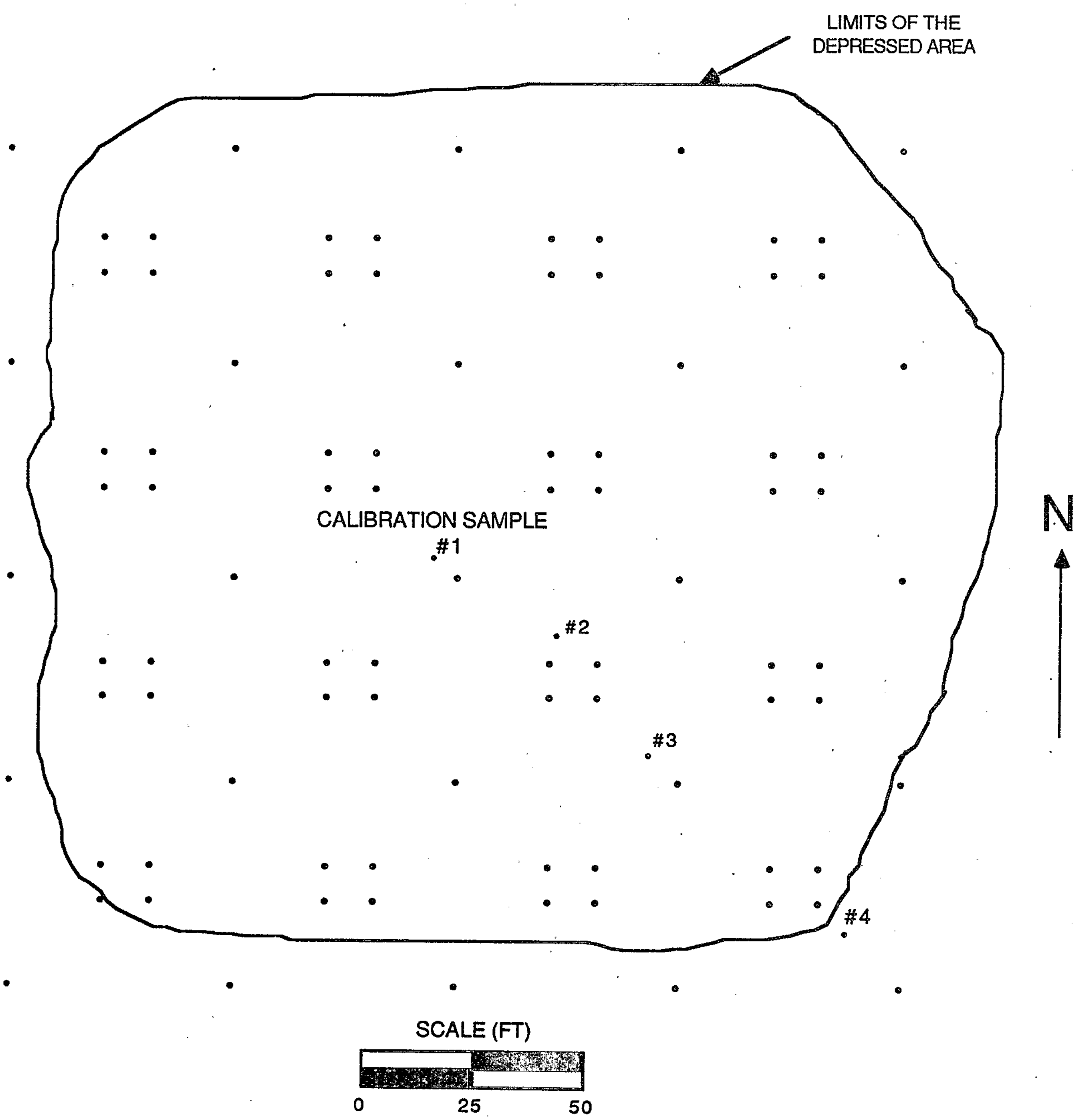


FIGURE 5-4
LOCATION OF CALIBRATION SAMPLES

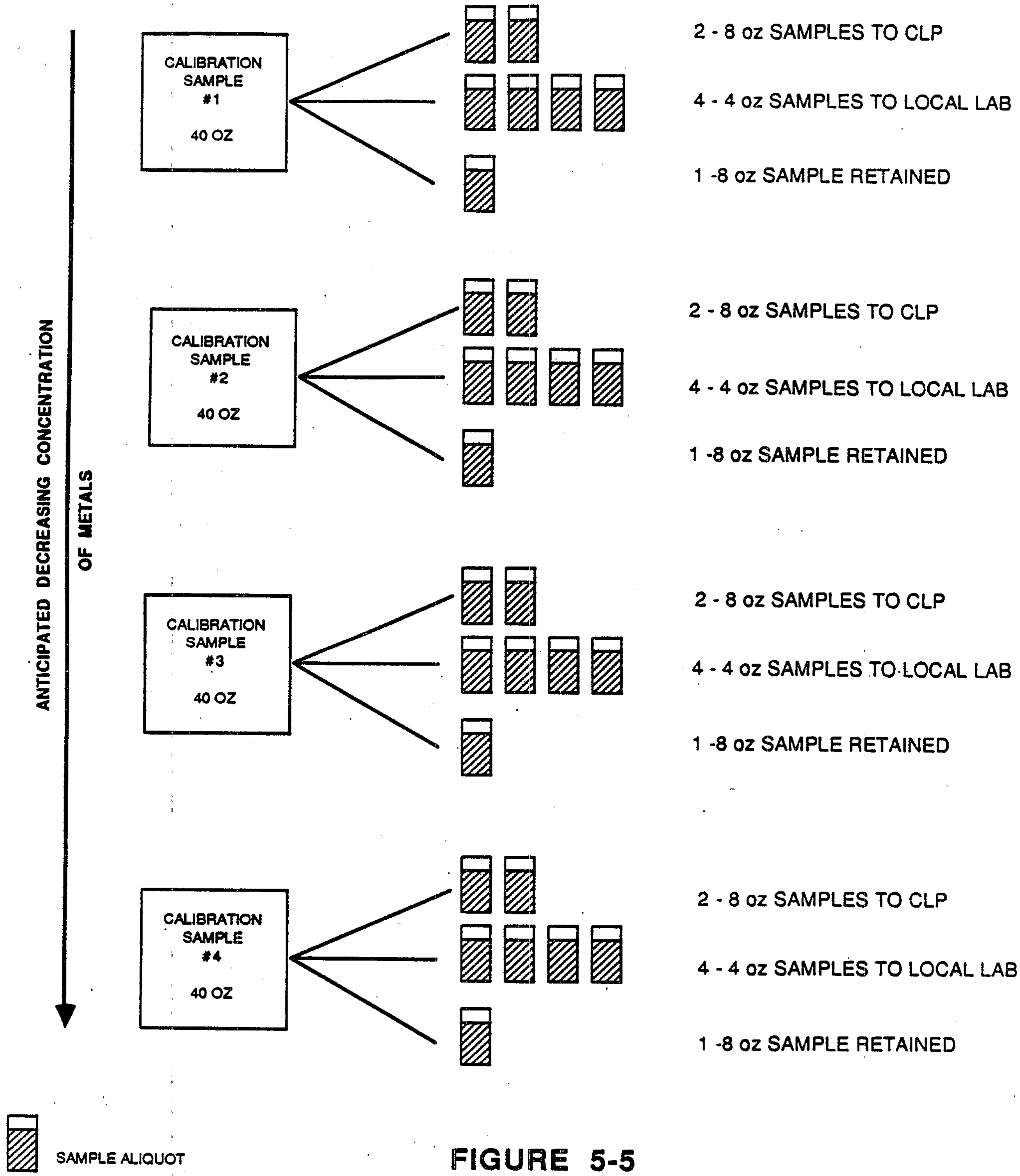


FIGURE 5-5
X-MET QC SAMPLES

be used to assess any matrix effects which might cause the site-specific accuracy and precision to be different from the historical accuracy and precision of CLP labs. The average of these two replicates will be considered the best estimate of the concentration of each calibration sample. Thus, the CLP analyses will serve to confirm the X-Met analyses. Because the CLP and the local lab independently measure the concentration of the calibration sample and the analyses are expected to follow normal distributions, the t-test can be used to state the confidence surrounding a conclusion that the CLP data do or do not support the X-Met calibration data.

The DQO process for this phase is summarized in Table 5-4.

5.3.6 REVIEW PARCC PARAMETER: RI PHASE IC - SURFACE SOIL INVESTIGATIONS

On site analysis of arsenic, chromium and lead using an X-Met x-ray fluorescence monitor has been selected. A rigorous field calibration procedure with off-site laboratory verification of the calibration standards will be used with this Level II procedure.

Precision - No historical precision data is available for this analytical technique. Replicate analysis of the calibration standards will allow estimation of the achieved precision.

Accuracy - A minimal amount of data for lead analysis is presented in Appendix A. The accuracy achieved will be calculated from the X-Met analysis of the CLP laboratory-verified calibration standards.

Representativeness - A sampling grid has been designed to obtain a representative picture of the metals contamination area.

Completeness - Since this is a field technique, 100 percent completeness can be achieved.

Comparability - The use of standard soil sampling procedures and a recognized field analytical procedure should make the resulting data comparable with other data of the same type.

5.4 STAGE 3 - DESIGN DATA COLLECTION PROGRAM: PHASE I REMEDIAL INVESTIGATIONS

Stage 3 of the DQO process is undertaken to integrate the detailed data collection program developed in Stage 2 and required to meet the RI/FS objectives. Figure 5-6 presents the elements necessary to design the data collection program. Through the process of addressing the elements identified in Stages 1 and 2, all the necessary components required for completion of Stage 3 should be available.

A phased RI/FS approach has been identified as the appropriate manner in which to collect and evaluate data for the example site. All the details required to identify the specific sampling components of the second phase of the RI would not be available during the initial scoping of the RI/FS.

The development of the S&A plan for Phase II would, therefore, be undertaken following completion of Phase I data collection and evaluation activities. The example provided herein identifies the general manner in which data collection documentation is developed. Work plans and S&A plans must comply with EPA requirements.

5.4.1 ASSEMBLE DATA COLLECTION COMPONENTS: PHASE I REMEDIAL INVESTIGATION

The intent of Stage 3 is to compile the information and DQOs developed for specific tasks into a comprehensive data collection program. This will allow the site manager and the RPM to identify field

TABLE 5-4
DQO SUMMARY FORM

1. SITE

NAME DQO DEMONSTRATION
LOCATION ______
NUMBER ______

EPA REGION ______

PHASE ______
RI 1 RI 2 RI 3 ERA FS RD RA
(CIRCLE ONE)

2. MEDIA *(CIRCLE ONE)*

SOIL	GW	SW/SED	AIR	BIO	OTHER ______

3. USE *(CIRCLE ALL THAT APPLY)*

SITE CHARAC. (H&S)	RISK ASSESS.	EVAL. ALTS.	ENGG DESIGN	PRP DETER.	MONITORING REMEDIAL ACTION	OTHER ______

4. OBJECTIVE SURFACE SOIL SAMPLES WILL BE TAKEN TO ASSESS THE INGESTION THREAT OF LEAD, ARSENIC, AND CHROMIUM WITHIN THE DEPRESSION

5. SITE INFORMATION

AREA 200 ft X 200 ft DEPRESSION DEPTH TO GROUND WATER 15 feet
GROUND WATER USE DRINKING WATER
SOIL TYPES GLACIAL TILL - DEPTH 0-30 ft; SHALE - DEPTH 30->100 ft
SENSITIVE RECEPTORS RESIDENTS 1 MILE EAST OF SITE

6. DATA TYPES *(CIRCLE APPROPRIATE DATA TYPES)*

A. ANALYTICAL DATA

pH	PESTICIDES	TOX
CONDUCTIVITY	PCB	TOC
VOA	METALS	BTX
ABN	CYANIDE	COD
TCLP	______	______

B. PHYSICAL DATA

PERMEABILITY	HYDRAULIC HEAD
POROSITY	PENETRATION TEST
GRAIN SIZE	HARDNESS
BULK DENSITY	______
______	______

7. SAMPLING METHOD *(CIRCLE METHOD(S) TO BE USED)*

ENVIRONMENTAL BIASED GRAB NON-INTRUSIVE PHASED
SOURCE GRID COMPOSITE INTRUSIVE ______

8. ANALYTICAL LEVELS *(INDICATE LEVEL(S) AND EQUIPMENT & METHODS)*

LEVEL 1 FIELD SCREENING - EQUIPMENT ______
LEVEL 2 FIELD ANALYSIS - EQUIPMENT X-MET WITH LEVEL 3 & 4 CONFIRMATION
LEVEL 3 NON-CLP LABORATORY - METHODS ______
LEVEL 4 CLP/RAS - METHODS ______
LEVEL NS NON STANDARD ______

9. SAMPLING PROCEDURES

BACKGROUND - 2 PER EVENT OR 3 SAMPLES
CRITICAL (LIST) 2 CLEAN SAMPLES IN EACH DIRECTION
PROCEDURES SAMPLE 0 to 2" DEPTH INTERVAL

10. QUALITY CONTROL SAMPLES *(CONFIRM OR SET STANDARD)*

A. FIELD
COLLOCATED - 5% OR ______
REPLICATE - 5% OR ______
FIELD BLANK - 5% OR ______
TRIP BLANK - 1 PER DAY OR ______

B. LABORATORY
REAGENT BLANK - 1 PER ANALYSIS BATCH OR ______
REPLICATE - 1 PER ANALYSIS BATCH OR ______
MATRIX SPIKE - 1 PER ANALYSIS BATCH OR ______
OTHER QC PROCEDURE DISCUSSED IN TEXT

11. BUDGET REQUIREMENTS

BUDGET $11,000 SCHEDULE 2 WEEKS FOR SAMPLING & INTERPRETATION
STAFF 2 SAMPLERS, 1 CHEMIST

CONTRACTOR ______ **PRIME CONTRACTOR** ______
SITE MANAGER ______ **DATE** ______

FOR DETAILS SEE SAMPLING & ANALYSIS PLAN CDM SF DQO 1.002

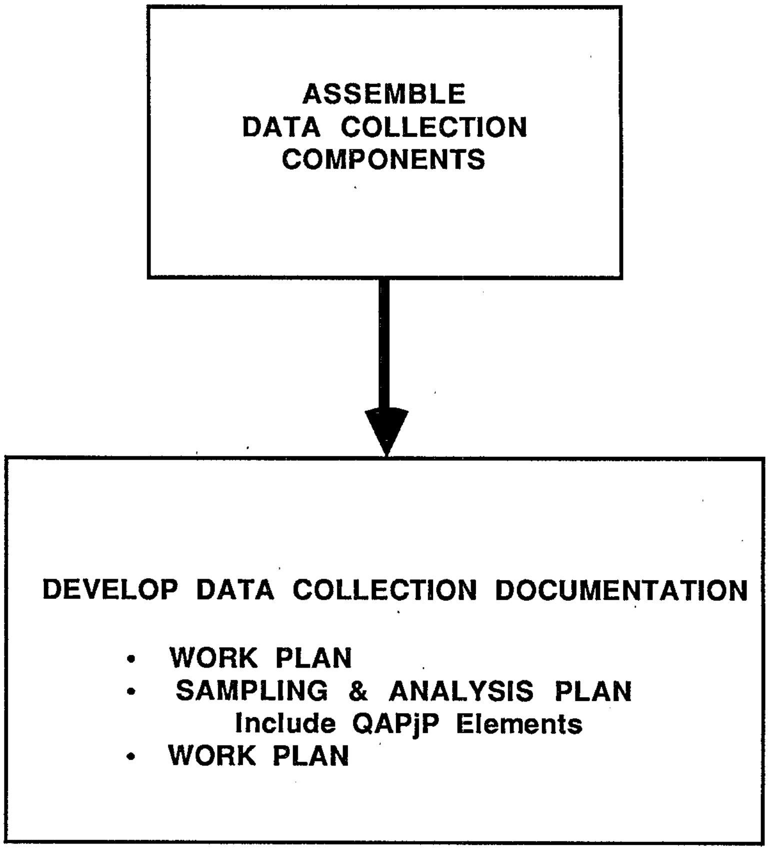


FIGURE 5-6
STAGE 3 ELEMENTS
DESIGN DATA COLLECTION PROGRAM

investigation tasks which could be undertaken simultaneously and thereby reduce costs associated with the RI/FS.

The data collection program should be developed to account for all sampling tasks and phases. During this process a detailed list of all samples to be obtained should be assembled as well as a schedule for all sampling activities.

5.4.2 DEVELOP DATA COLLECTION DOCUMENTATION: PHASE I REMEDIAL INVESTIGATIONS

The result of applying the DQO process is a well defined sampling and analysis plan with summary information provided in the work plan. Quality assurance project plan (QAPjP) elements should be included in the S&A plan and the work plan.

Sampling and Analysis Plan

Separate S&A plans will be prepared for each of the two phases of the remedial investigation.

For Phase I of the RI, S&A components should be written for each individual activity including the following:

- Existing well sampling
- Soil gas sampling
- Soil sampling (metals)

The following information will be provided in the Phase I S&A plan for the example site:

- Number of samples to be obtained from the existing wells, soil gas sampling and the soil (metals) sampling
- Number of QA/QC samples including field blanks, trip blanks collocated samples; method blanks, laboratory replicates and matrix spikes
- Identification of sampling locations and numbering system
- Prioritized listing of the sequence in which samples are to be taken from the existing wells, etc.
- List of critical samples for each media
- List of analyses which will be performed
- Chain of custody for samples transported off-site
- Instrument calibration and maintenance procedures

The standard sections of a quality assurance project plan (QAPjP), are listed in Table 5-5. Details on preparation of QAPjPs are contained in Interim Guidelines and Specification for Preparing QAPjPs (EPA 1980). The required information should be addressed in the S&A Plan.

TABLE 5-5
DATA COLLECTION COMPONENTS - PHASE I

RI PHASE	MEDIA	SAMPLE TYPE	NUMBER OF SAMPLES	NUMBER OF QA/QC SAMPLES
IA	GROUND WATER	GRAB	3 RESIDENTIAL WELLS	4 REPLICATES 4 MATRIX SPIKE
			2 ON-SITE WELLS	1 DUPLICATE 1 SPIKE
IB	GROUND WATER/SOIL	SOIL GAS	52[1]	NA
IC	SOIL	GRAB	89	60[2]
2A	GROUNDWATER	GRAB	5*	
2B	SOIL	AUGER	100*	

NA - Not applicable - calibration standards will be run daily

1 Forty-nine initial soil gas samples will be taken on a regular grid pattern. This grid will also be extended at 50 ft. intervals until 2 clean sample are obtained. In addition, 3 background samples will be obtained.

2 See Section 5.3.5 for details

* Estimates of number of samples included for costing purposes. May be revised after evaluation of phase I data.

Work Plan

Work plans define the scope of services, level of effort, costs, and schedule for performing the RI/FS. The work plan provides a general description of how all tasks and activities will be undertaken. However, it would not contain the detailed description of how each sample is obtained or how the analysis is performed, which is presented in the sampling and analysis plan. Table 5-6 provides a summary of data collection components for the example site and Figure 5-7 provides a schedule for RI activities.

The level of detail in the work plan for the example RI site is outlined below:

- A brief description of the level of personnel protection to be used in the field. For a detailed description of health and safety concerns, the health and safety plan is referenced.

- Number of individuals to be involved in each field sampling task and estimated duration in days, including time for mobilization and demobilization.

- Approximate locations of soil sampling, existing and new wells will be provided, since costs associated with obtaining samples can vary with different sampling locations. Costs for drilling will also vary depending on location.

- How data will be validated, compiled and evaluated. Data validation efforts require 2 to 3 hours per sample for complete HSL packages.

5.5 DQO STAGE 1 - COLLECT AND EVALUATE DATA: PHASE I REMEDIAL INVESTIGATIONS

This section presents a general review of the data collected during Phase I of the RI. The data collection (i.e., actual field investigations) and evaluation steps (DQO Stage 1) take place at the conclusion of Stage 3 of the DQO process. In order to simplify the discussion, the elements of Stage 1 will be presented in an abbreviated form. The DQO Stage 1 process must be repeated (usually in an abbreviated form) whenever significant amounts of new data are collected.

5.5.1 ANALYSIS OF RESULTS: RI PHASE IA - EXISTING WELL SAMPLING

The analysis of water from the private wells during Phase IA of the RI confirms that the wells are not contaminated. These data support and confirm the analytical results obtained during the FIT investigation. The data was validated by the analytical chemists and accepted by the RPM. As a result of this data evaluation, the RPM and the contractor's site manager have determined that no alternate water supply is required for the protection of public health and welfare.

Analyses of ground water from the two on-site wells further confirmed the results of the FIT investigation. Contaminants were not detected in the background upgradient well (OW2) and only TCE was detected in OW1. TCE was detected in comparable levels to that reported by the FIT analyses. A monitoring program will be implemented to ensure the continued potability of the residential drinking water. This program will consist of quarterly testing of each private well. Further, monitoring wells installed as part of the Phase II effort will also be tested quarterly.

5.5.2 ANALYSIS OF RESULTS: RI PHASE IB - SOIL GAS SAMPLING

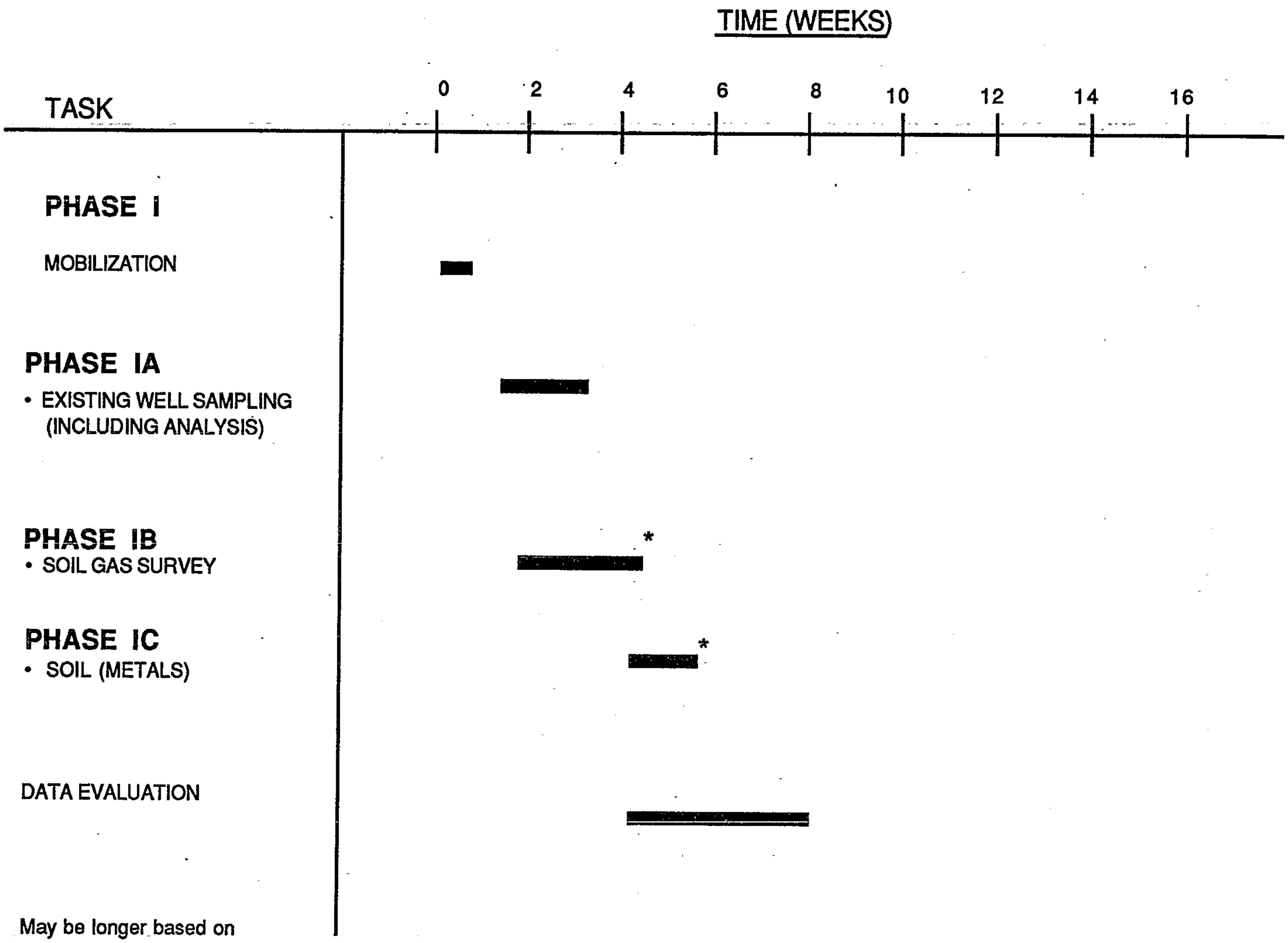
The soil gas analysis confirmed the presence of a volatile organic plume originating in the depression and migrating toward the east. These data are presented graphically in Figure 5-8. Specifically, the results of the GC analyses have shown that while all compounds were consistently detected within the actual source areas (as defined by discolored soil), all compounds showed a rapid decrease in concentration as a function of distance from the center of the source area.

TABLE 5-6

EXAMPLE SITE
QUALITY ASSURANCE PROJECT PLAN ELEMENTS

		QAPjP SECTIONS	EXAMPLE SITE INFORMATION PROVIDED IN
1	-	Title Page Introduction	S&A Plan
2	-	Table of Contents	S&A Plan
3	-	Project Description	Work Plan
4	-	Project Organization and Responsibility	Work Plan
5	-	Quality Assurance Objectives for Data Measurement	S&A Plan
6	-	Sampling Procedures	S&A Plan Referenced SOPs
7	-	Sample and Document Custody Procedures	Referenced SOPs
8	-	Calibration Procedures and Frequency	Referenced SOPs
9	-	Analytical Procedures	CLP IFB and S&A Plan
10	-	Data Reduction, Validation, and Reporting	Referenced SOPs and QAPP*
11	-	Internal Quality Control Checks	QAPP
12	-	Performance and System Audits	QAPP
13	-	Preventive Maintenance	QAPP and SOPs
14	-	Data Measurement Assessment Procedures	CLP IFB and SOPs
15	-	Corrective Action	QAPP
16	-	Quality Assurance Reports to Management	QAPP

*Agency and contractor quality assurance program plan



* May be longer based on the extent of contamination

FIGURE 5-7
PHASE I REMEDIAL INVESTIGATION SHEDULE

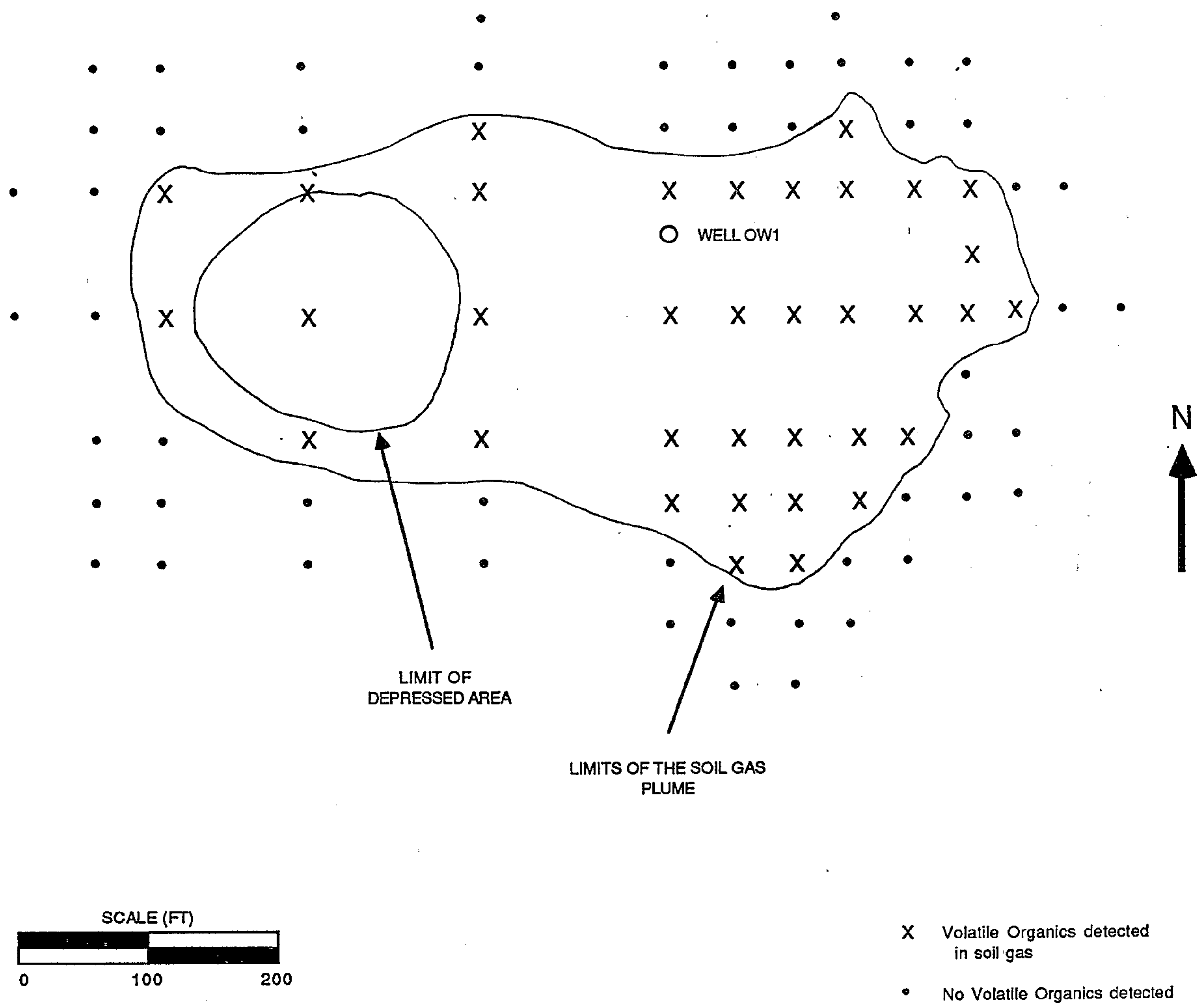


FIGURE 5-8
RESULTS OF SOIL GAS SAMPLING

Outside the boundary of the source area, TCE was the only compound detected in appreciable concentrations. The presence of volatile organics in the soil gas outside the bounds of the soil depression may be indicative of the movement of the ground water plume in an easterly direction.

The results of Phase I soil gas sampling indicate a need to obtain additional soil samples (at depth) in order to determine the extent of soil contamination. Samples of ground water encountered within the area delineated by the soil gas plume should also be obtained to determine if the soil gas plume data can be correlated to the ground water contaminant levels.

5.5.3 ANALYSIS OF RESULTS: RI PHASE IC - SURFACE SOIL SAMPLING

5.5.3.1 Calibration of X-Met (Precision and Accuracy achieved for metals analysis)

To calibrate the X-Met, four calibration samples were taken along a radial line from the center of the depressed area. The sample locations were shown in Figure 5-4. Each of the four samples was split into seven replicate samples as shown in Figure 5-5. Four replicates from each sample or 16 samples were sent to a local lab with an in-place QA/QC program and were analyzed for lead, chromium, and arsenic. Only the results for the lead samples are discussed here since the analysis performed for the other elements is analogous. Table 5-7 summarizes the results for lead.

The average of the four replicate analyses was taken as the actual value for each of the four calibration samples and the X-Met was calibrated using these values. During analyses of actual samples, each of the calibration samples were run 15 times. Based on the X-Met analyses of the replicates, the accuracy and precision can be expressed as a function of concentration. Accuracy will be expressed in terms of bias where bias is expressed as:

$$\text{Bias} = \frac{\overline{X} - A}{A}$$

Where:

$\overline{X}$ is the mean of the 15 replicates, and

A is the concentration determined from samples sent to the local lab.

Precision will be expressed as the standard deviation of the 15 replicates. The accuracy and precision of the X-Met are presented in Table 5-8.

Table 5-8 shows that the X-Met has accuracy values which are within ± 10 percent over the entire range of concentration. This is an acceptable accuracy value and indicates that the X-Met should, on average, accurately reproduce the contaminant levels throughout the site.

Given the accuracy and precision of the X-Met analyses, the detection limit for the method can be determined. When the X-Met results are reported, it is extremely unlikely that the reported values will be exactly equal to the actual value. This analytical error is expected and acceptable; however, it is generally not acceptable to report a positive concentration for a compound when, in fact, the compound is not present in the sample. The use of a detection limit lowers the risk of this occurrence to an acceptable level. For X-Met analyses (lead in this case), the detection limit will be set so that when a value is reported above the detection limit, there will be greater than a 99 percent chance that lead is actually present in the sample.

TABLE 5-7
RESULTS OF REPLICATE ANALYSES FOR LEAD (CALIBRATION SAMPLES)

	REPLICATE #					
SAMPLE #	1	2	3	4	MEAN	S.D.
1	178	171	192	183	181	8.8
2	811	777	820	840	812	26.3
3	263	287	242	277	267	19.3
4	5	4	8	6	5.8	1.7

ALL UNITS IN mg/kg

S.D. = STANDARD DEVIATION

TABLE 5-8
ACCURACY AND PRECISION OF THE X-MET
(Results of Lead Analysis- mg/kg)

CALIBRATION SAMPLE #	PB CONCENTRATION (LOCAL LAB)	MEAN X-MET CONCENTRATION	ACCURACY	PRECISION	PRECISION/MEAN
4	5.8	5.5	-.05	2.7	.46
1	181	162	-.10	6.2	.03
3	267	278	.04	7.2	.03
2	812	800	-.02	14.0	.02

The detection limit will be based on the distribution of analytical errors. In this example, the distribution of analytical errors is the distribution of errors for calibration sample #4. This sample was chosen since it has the lowest concentration of lead and is therefore most representative of the performance of the X-Met at low concentrations.

The distribution of the 15 replicates of calibration sample #4 is normal, with a mean of 5.5 mg/kg and a standard deviation of 2.4 mg/kg. The actual concentration of sample #4 is 5.0 mg/kg. Thus the average error is 0.5 mg/kg and the distribution of errors is normal, with a mean of 0.5 mg/kg and a standard deviation of 2.4.

Based on the above assumption, the detection limit can be determined as:

$$\Pr(Z < D) \geq 99\%$$

where Z is an error
D is the detection limit

Since the errors are normally distributed, a normal probability table can be used to determine the detection limit D. The standard normal variable corresponding to 99% probability is 2.33 (see Table 5-9). The detection limit is then:

$$\frac{D - m}{s} = 2.33$$

where s is the standard deviation, and

m is the average error

$$\frac{D - (-.3)}{2.17} = 2.33$$

$$D = 5.99 \text{ mg/kg}$$
$$= 6.0 \text{ mg/kg}$$

So, if the X-Met reports greater than 6.0 mg/kg lead there is at least a 99 percent chance that lead is present in the sample. If the X-Met reports less than 6 mg/kg, a value of 3 mg/kg will be used as an estimate of the concentration. A non-zero concentration is reported when lead is below the detection limit because lead is present to some degree in all surface soils. The value 3 mg/kg is attributed to soils with non-detectable lead concentrations because this value is thought to adequately represent the background lead concentration in the site area.

5.5.3.2 Geostatistical Analysis of Surface Soil Sampling Results

Samples were collected and analyzed at each of the 89 locations on the hybrid grid. Samples were analyzed for lead, arsenic, and chromium. Only the results for lead are discussed here. The lead concentrations found at each sample location are shown in Figure 5-9. Contours of the data indicate that the proposed conceptual model for this site is incorrect. Contamination does not occur in small isolated pockets; rather, there are two large contaminated zones. The two contaminated zones are bounded by zones of undetectable lead contamination, so the horizontal extent of the contamination is known.

TABLE 5-9

PROBABILITY TABLE

Table of the Cumulative Distribution of a Standard Normal Random Variable

k	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.50000	0.50399	0.50798	0.51197	0.51595	0.51994	0.52392	0.52790	0.53188	0.53586
0.1	0.53983	0.54380	0.54776	0.55172	0.55567	0.55962	0.56356	0.56749	0.57142	0.57535
0.2	0.57926	0.58317	0.58706	0.59095	0.59483	0.59871	0.60257	0.60642	0.61026	0.61409
0.3	0.61791	0.62172	0.62552	0.62930	0.63307	0.63683	0.64058	0.64431	0.64803	0.65173
0.4	0.65542	0.65910	0.66276	0.66640	0.67003	0.67364	0.67724	0.68082	0.68439	0.68793
0.5	0.69146	0.69497	0.69847	0.70194	0.70540	0.70884	0.71226	0.71566	0.71904	0.72240
0.6	0.72575	0.72907	0.73237	0.73565	0.73891	0.74215	0.74537	0.74857	0.75175	0.75490
0.7	0.75804	0.76115	0.76424	0.76730	0.77035	0.77337	0.77637	0.77935	0.78230	0.78524
0.8	0.78814	0.79103	0.79389	0.79673	0.79955	0.80234	0.80511	0.80785	0.81057	0.81327
0.9	0.81594	0.81859	0.82121	0.82381	0.82639	0.82894	0.83147	0.83398	0.83646	0.83891
1.0	0.84134	0.84375	0.84614	0.84849	0.85083	0.85314	0.85543	0.85769	0.85993	0.86214
1.1	0.86433	0.86650	0.86864	0.87076	0.87286	0.87493	0.87698	0.87900	0.88100	0.88298
1.2	0.88493	0.88686	0.88877	0.89065	0.89251	0.89435	0.89617	0.89796	0.89973	0.90147
1.3	0.90320	0.90490	0.90658	0.90824	0.90988	0.91149	0.91309	0.91466	0.91621	0.91774
1.4	0.91924	0.92073	0.92220	0.92364	0.92507	0.92647	0.92785	0.92922	0.93056	0.93189
1.5	0.93319	0.93448	0.93574	0.93699	0.93822	0.93943	0.94062	0.94179	0.94295	0.94408
1.6	0.94520	0.94630	0.94738	0.94845	0.94950	0.95053	0.95154	0.95254	0.95352	0.95449
1.7	0.95543	0.95637	0.95728	0.95818	0.95907	0.95994	0.96080	0.96164	0.96246	0.96327
1.8	0.96407	0.96485	0.96562	0.96638	0.96712	0.96784	0.96856	0.96926	0.96995	0.97062
1.9	0.97128	0.97193	0.97257	0.97320	0.97381	0.97441	0.97500	0.97558	0.97615	0.97670
2.0	0.97725	0.97778	0.97831	0.97882	0.97932	0.97982	0.98030	0.98077	0.98124	0.98169
2.1	0.98214	0.98257	0.98300	0.98341	0.98382	0.98422	0.98461	0.98500	0.98537	0.98574
2.2	0.98610	0.98645	0.98679	0.98713	0.98745	0.98778	0.98809	0.98840	0.98870	0.98899
2.3	0.98928	0.98956	0.98983	0.99010	0.99036	0.99061	0.99086	0.99111	0.99134	0.99158
2.4	0.99180	0.99202	0.99224	0.99245	0.99266	0.99286	0.99305	0.99324	0.99343	0.99361
2.5	0.99379	0.99396	0.99413	0.99430	0.99446	0.99461	0.99477	0.99492	0.99506	0.99520
2.6	0.99534	0.99547	0.99560	0.99573	0.99585	0.99598	0.99609	0.99621	0.99632	0.99643
2.7	0.99653	0.99664	0.99674	0.99683	0.99693	0.99702	0.99711	0.99720	0.99728	0.99736
2.8	0.99744	0.99752	0.99760	0.99767	0.99774	0.99781	0.99788	0.99795	0.99801	0.99807
2.9	0.99813	0.99819	0.99825	0.99831	0.99836	0.99841	0.99846	0.99851	0.99856	0.99861
3.0	0.99865	0.99869	0.99874	0.99878	0.99882	0.99886	0.99889	0.99893	0.99896	0.99900
3.1	0.99903	0.99906	0.99910	0.99913	0.99916	0.99918	0.99921	0.99924	0.99926	0.99929
3.2	0.99931	0.99934	0.99936	0.99938	0.99940	0.99942	0.99944	0.99946	0.99948	0.99950
3.3	0.99952	0.99953	0.99955	0.99957	0.99958	0.99960	0.99961	0.99962	0.99964	0.99965
3.4	0.99966	0.99968	0.99969	0.99970	0.99971	0.99972	0.99973	0.99974	0.99975	0.99976
3.5	0.99977	0.99978	0.99978	0.99979	0.99980	0.99981	0.99981	0.99982	0.99983	0.99983
3.6	0.99984	0.99985	0.99985	0.99986	0.99986	0.99987	0.99987	0.99988	0.99988	0.99989
3.7	0.99989	0.99990	0.99990	0.99990	0.99991	0.99991	0.99992	0.99992	0.99992	0.99992
3.8	0.99993	0.99993	0.99993	0.99994	0.99994	0.99994	0.99994	0.99995	0.99995	0.99995
3.9	0.99995	0.99995	0.99996	0.99996	0.99996	0.99996	0.99996	0.99996	0.99997	0.99997
4.0	0.99997	0.99997	0.99997	0.99997	0.99997	0.99997	0.99998	0.99998	0.99998	0.99998

Reference: Olkin et. al, 1972

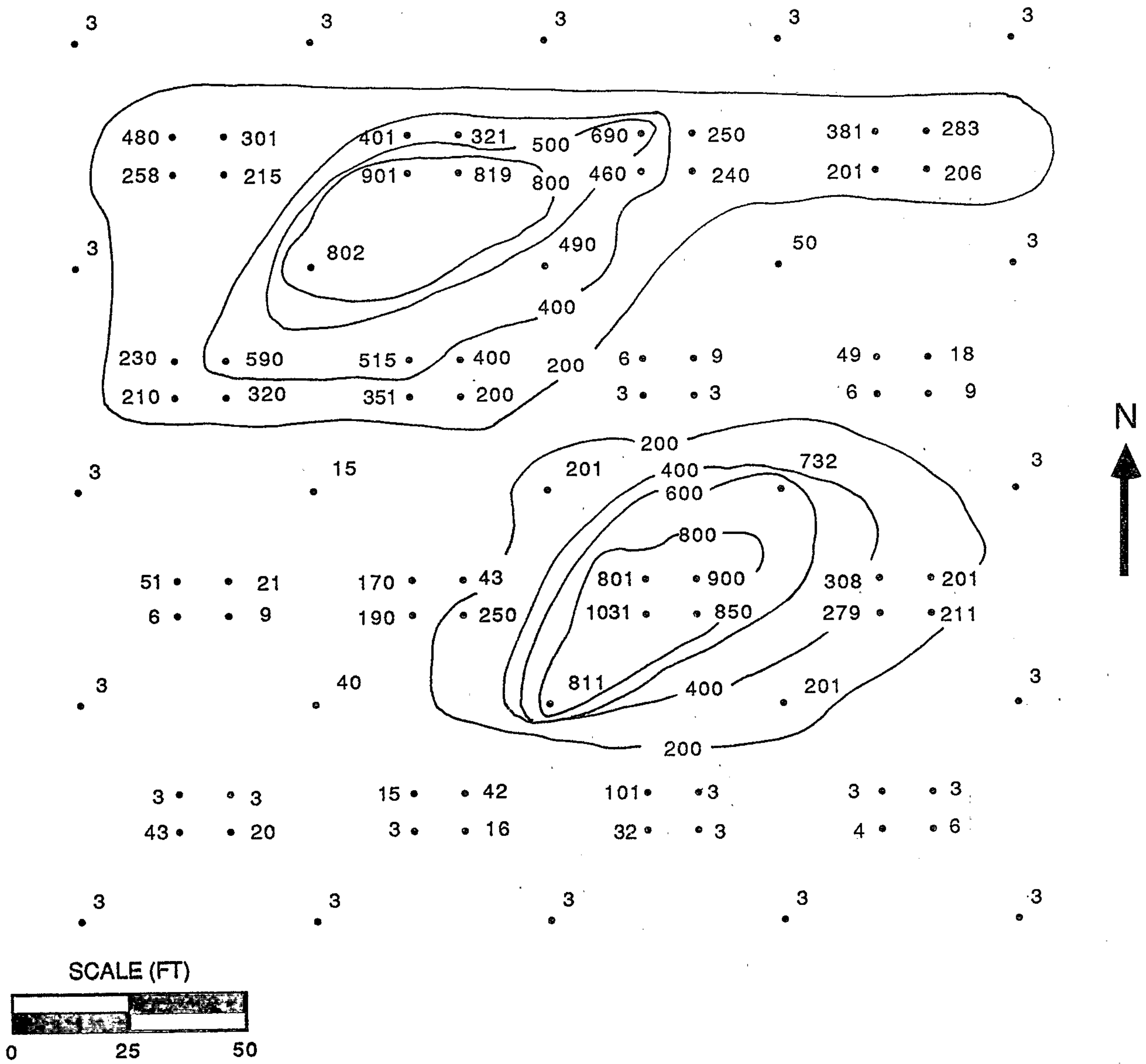


FIGURE 5-9
LEAD CONCENTRATION CONTOURS
(VALUES IN mg/kg)

The first step in the analysis of these data is to determine the mean lead concentration within the depressed area. This mean value can be used in an exposure assessment as the expected concentration of lead which will be encountered. A simple averaging of the 89 data points gives a mean value of 207 mg/kg lead. This mean value is not, however, representative of the true mean lead concentration.

The data within the depressed zone are collected according to a hybrid grid. This grid contains data points separated by 10 ft and data points separated by 50 ft. The data points located on the 50-ft grid provide much more valuable information concerning the mean than the data points on the 10-ft grid due to the spatial correlation of the data. Because the data are spatially correlated, samples taken very close together are expected to have similar values. Two samples, taken close together, yield little additional information over one sample concerning overall site properties. Since two closely located samples provide little more information than one sample, such samples should not be counted as two separate samples when calculating the mean. Thus, closely located samples must be down weighted when calculating a mean.

In this case the data points located on the 10-ft grid have much stronger correlation than the data points located on the 50-ft grid. Or, in other words, the 10-ft data points are less valuable and must be down weighted.

The undue influence of the 10-ft data is removed by averaging the four data within each of the 16 groups of samples separated by 10 ft to produce 16 new values which are located at the center of each of the 50-ft cells. This procedure yields 41 data located on a regular 71-ft grid. Since these 41 data are located on a regular grid, they have equal correlation and provide equally valuable information for estimating the mean. The average of these 41 values is 174 mg/kg. This value is the best estimate of the mean concentration of lead within the depressed area.

To obtain a reasonable worst case value for the risk assessment, the value which represents a 10 percent chance of exposure will be determined. This value will be determined by examining the histogram of the 41 data which provide equal site coverage.

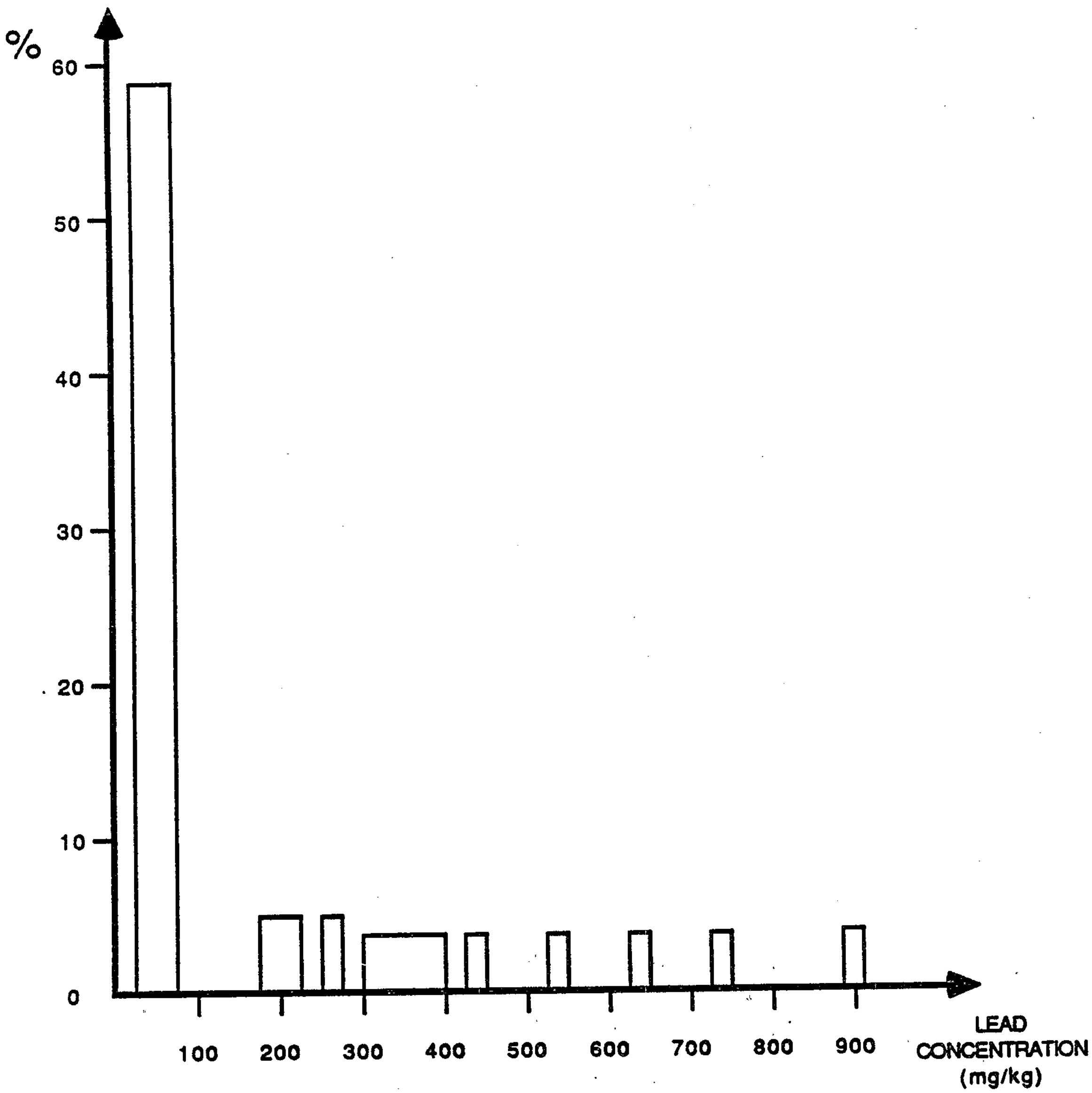
The histogram provides an experimental measure of the likelihood of a sample concentration falling between any two concentrations of interest. The histogram of lead data is shown as Figure 5-10. The histogram shows, for example, that 7 percent of the data fall between 200 and 300 mg/kg. In addition, the histogram indicates that approximately 10 percent of the data and equivalently 10 percent of the soil in the depressed area has lead concentrations in excess of 735 mg/kg. Therefore there is a 10 percent chance that an exposure of at least 735 mg/kg will be received. This value can be used in an exposure assessment as a reasonable worst-case exposure.

Given an estimate of the mean lead concentration within the depressed area, the next quantity of interest is the uncertainty surrounding this estimate. As discussed in the guidance document, the uncertainty associated with an estimate of concentration can be determined once a model of the site-specific spatial correlation is available. This model will be obtained by modeling the variogram of the available data.

The variogram model describes the spatial variability of the data as a function of distance. It is determined by modeling the experimental variogram of the data which is calculated by grouping pairs of data into distance classes and calculating a type of variance measure for each pair of data. For instance at this site, 64 pairs of data are separated by 10 ft. For each pair of these data, the following variability measure is calculated

$$g = 1/2\,(X_1 - X_2)^2$$

where g is the variability measure. and
X_1 and X_2 are data separated by 10 ft



Number of data = 41
Mean = 174.4
Variance = 68012.3
Coefficient of variation = 1.50

FIGURE 5-10
HISTOGRAM OF LEAD CONCENTRATION
(mg/kg)

This measure is then calculated for all 63 other pairs of data and the average of the 64 variability measures is obtained. This average value is the average spatial variability or correlation of data separated by 10 ft. Similarly, the spatial variability (variogram) of data separated by 20 ft, 30 ft, 40 ft, and so on can be calculated. Plotting the experimental variogram versus distance gives a pictorial representation of the spatial variability as a function of distance (see Figure 5-11).

In the majority of cases an experimental variogram shows three features: (1) at zero distance the variogram is non zero, (2) as distance increases the variogram increases linearly, and (3) at some distance the variogram will level off and remain constant. The first feature of the variogram is essentially the variance of data separated by very small distances. This variance comprises the variability of the analytical method, the sampling method and the intrinsic variability of contaminants and is typically many times larger than the analytical precision.

The linear increase of the variogram is due to the fact that when data are separated by greater and greater distances, the spatial variability of the data increases or, in other words, the correlation decreases. This relationship is expected since it is intuitive that data separated by small distances will have more similar values than data separated by large distances. However, spatial variability does not continue to increase for all distances. Beyond some site specific distance variability will cease increasing. This distance is known as the range of correlation. If a pair of data are separated by a distance greater than the range of correlation, the data are not correlat This average value is the average spatial variability or correlation of data separated by 10 ft. Similarly, the spatial variability (variogram) of data separated by 20 ft, 30 ft, 40 ft, and so on can be calculated. Plotting the experimental variogram versus distance gives a pictorial representation of the spatial variability as a function of distance (see Figure 5-11).

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The experimental variogram for lead shows the three general features of the variogram. At zero distance a non zero variability is observed. Variability increases until a distance of 75 ft is reached. After this distance, variability ceases increasing. A model which incorporates these three features has been fit to the experimental variogram (Figure 5-11). This model is known as a spherical model. The model fits well for distances less than 50 ft, however, the fit is not good at greater distances since the experimental data show a slight periodicity. This periodicity can be modeled; however, the complexity of the model would be increased significantly and the increased usefulness of the model would be slight. In short, a more complex variogram model would increase the costs of performing this study but would not influence the results. For this reason, the spherical model fit to the experimental values will be acceptable.

Once the variogram model is known, the uncertainty associated with the estimate of the mean can be determined. This uncertainty is expressed as a variance and is termed the estimation variance. The variogram model can also be used to determine uncertainty as a function of the number of data. Hence the

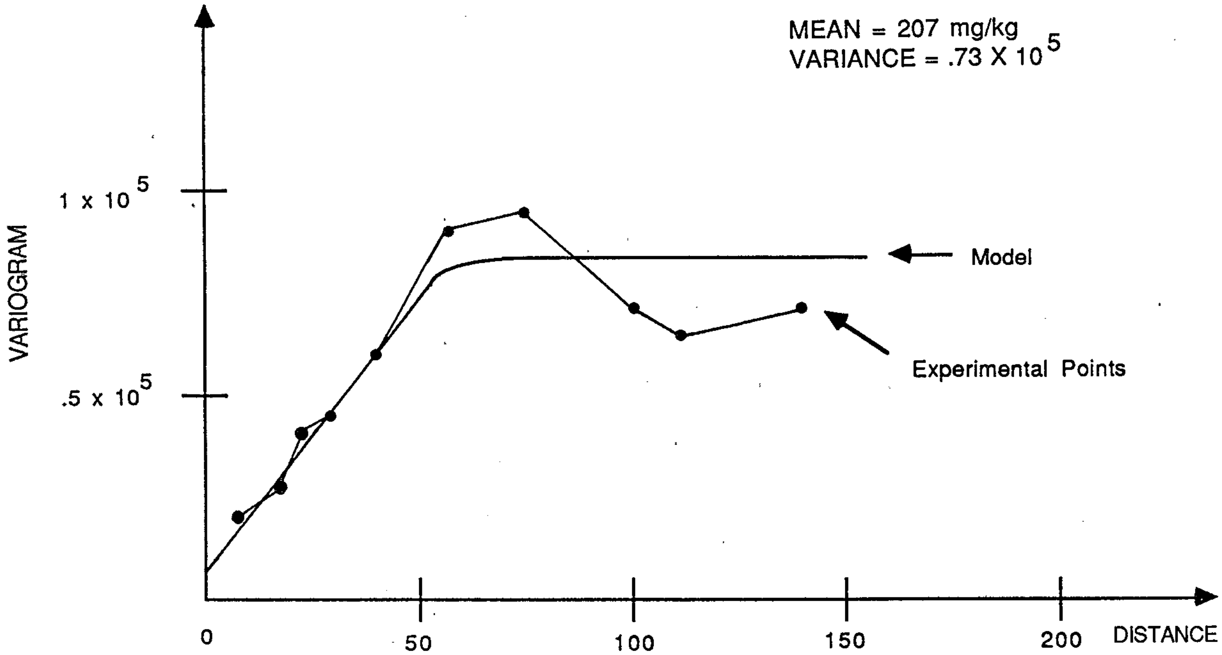

FIGURE 5-11
VARIOGRAM OF LEAD CONCENTRATIONS

variogram model can be used to determine how many data are required to lower the uncertainty to an acceptable level. The techniques used to determine the estimation variance are beyond the scope of this document but are described briefly in the guidance manual.

The estimation variance associated with the estimate of mean lead concentration at the site is 350 $(mg/kg)^2$. This estimation variance was determined using the variogram model. Given this variance, confidence limits can be set. Assuming a normal distribution of the means, the 95 percent confidence limits on the mean site lead concentration are:

$$Z_{.025} < m < Z_{.975}$$

$$\frac{L_1 - X}{S} < m < \frac{L_2 - X}{S}$$

$Z_{.175}$, $Z_{.025}$ are known from a standard normal table (Table 5-8)

$\overline{X}$ is the estimated mean lead concentration = 174

S is the square root of the estimation variance = 18.3

L_1 and L_2 are the confidence limits

$$Z_{.025} = \frac{L_1 - X}{S}$$

$$L_1 = Z_{.025}\, S + X$$

$$L_1 = (-1.96)(18.3) + 174$$
$$= 138$$

Similarly

$$L_2 = 210$$

Based on this analysis 95 percent of the time the true mean will fall between 138 and 210 mg/kg. This statement is a numerical data quality statement which for this example is the output of the DQO process.

The confidence interval can be used to assess whether the available data are sufficient for the data uses. The primary use for this data is as input into a risk assessment model. The confidence limits are approximately $\pm$ 20 percent ((1.96)(18.3)/174) of the estimated mean. Given the data uses this confidence level is deemed acceptable. Additional data are not required.

6

DQO DEVELOPMENT PHASE II REMEDIAL INVESTIGATIONS

6.0 DQO DEVELOPMENT - PHASE II REMEDIAL INVESTIGATION

6.1 DQO STAGE 2 - IDENTIFY DATA USES AND NEEDS: RI PHASE IIA - GROUND WATER INVESTIGATION

6.1.1 IDENTIFY DATA USES: RI PHASE IIA - GROUND WATER INVESTIGATION

During Phase I of the RI, ground water samples were obtained from the on-site wells and three private water supply wells located east of the site. The samples obtained from the private wells did not contain detectable levels of volatile organics or other compounds which would require that alternative water supplies be provided. The soil gas analyses, however, indicate that volatile organics are present in the ground water. The ground water plume appears to be migrating eastward and could potentially affect the private wells.

Ground water data are required in this phase to evaluate the extent of contamination, to develop a risk assessment, and to evaluate the potential remedial alternatives for the site.

Data uses and the DQO summary for this phase are provided in Table 6-1.

6.1.2 IDENTIFY DATA TYPES: RI PHASE IIA - GROUND WATER INVESTIGATIONS

The types of data required in this phase are varied. To satisfy the data uses, ground water monitoring wells will be installed. All wells will be screened in the unconfined aquifer. No wells are planned in deeper aquifers since these aquifers are brackish and therefore non-potable. The types of data which will be obtained from testing the monitoring wells are contaminant concentrations, general water quality information, hydraulic head, and horizontal hydraulic conductivity. Additional data types will be measured during monitoring well installation. Soil samples can be taken to measure soil contaminant levels, porosity, vertical permeability, and other general soil properties including particle size distribution, density, and standard penetration tests.

In this example document, it is not feasible to discuss all the considerations associated with each of the identified data types. For this reason the document will focus on the concentration of contaminants within the ground water as this type of information (used for site characterization, risk assessment, and evaluation of alternatives) is the most commonly collected and discussed type of ground water data.

Soil gas analyses for volatile organics indicate that TCE is the primary contaminant of concern outside of the depressed area. Ground water sampling and analysis will be undertaken to identify and confirm the concentration of TCE, other volatile organics, and metals and to obtain general water quality information in the shallow aquifer. This information will be used in conjunction with data on aquifer characteristics to develop the risk assessment.

6.1.3 IDENTIFY DATA QUALITY NEEDS: RI PHASE IIA - GROUND WATER INVESTIGATION

Data Quality Factors

Prioritized Data Uses:	Risk Assessment Evaluation of Alternatives
Appropriate Analytical Levels:	Risk Assessment: Level III, IV, V Evaluation of Alternatives: II, III, IV
Contaminants of Concern:	TCE, Arsenic, Chromium, Lead

TABLE 6-1
DATA USES

SITE
NAME DQO DEMONSTRATION
LOCATION ____________
NUMBER ____________
PHASE ____________
RI1 RI2 RI3 ERA FS RD RA

EPA REGION ____________

DATE ____________
CONTRACTOR ____________
SITE MANAGER ____________

DATA USE / MEDIA	SITE CHARACTERIZATION (INCLUDING HEALTH & SAFETY)	RISK ASSESSMENT	EVALUATION OF ALTERNATIVES	ENGINEERING DESIGN OF ALTERNATIVES	MONITORING DURING REMEDIAL ACTION	PRP DETERMINATION	OTHER ____
SOURCE SAMPLING TYPE ____							
SOIL SAMPLING		X	X	X			
GROUND WATER SAMPLING		X	X				
SURFACE WATER/SEDIMENT SAMPLING							
AIR SAMPLING							
BIOLOGICAL SAMPLING							
OTHER ____							

NOTE: CHECK APPROPRIATE BOX (ES)

CDM SF DQO 1.001

Levels of Concern:	5 ppb TCE/50 ppb Metals
Required Detection Limit:	2 ppb TCE
Critical Samples:	Wells MW1, MW2

Monitoring wells will be installed following procedures which will be outlined in Section 6.1.6. Well locations will be chosen to accomplish the following specific goals: (1) measure contaminant concentrations within the ground water plume and (2) serve as an early warning system to detect the migration of contaminants towards the residential wells. Because of the differing goals of the monitoring wells, different data quality, as expressed by analytical level, will be required.

Analysis of water from the early warning wells will be conducted by Method 601/602 to allow detection of volatile organic contaminants near 1 ppb. Since the potential level of concern for volatile organics tends to be in the low ppb range, the detection limits for this method are acceptable to meet the objectives of Phase IIA. Method 601/602 can be performed by CLP SAS. Analysis of water from the remaining wells can be accomplished by Method 624, which has 5-ppb detection level for TCE. Since turnaround time is not a major issue, these samples will be sent to the CLP (RAS) for analysis.

Ground water samples from the newly installed wells will also be analyzed for lead, chromium and arsenic. The CLP RAS Contract Required Detection Limit (CRDL) of 5 ug/l, 10 ug/l and 10 ug/l respectively will be required for this phase. Based on the MCL values of 50 ug/l for arsenic, lead, and chromium, CLP RAS detection limits of 5 to 10 ug/l are sufficiently low (see Appendix B).

Methods available to accomplish these analyses are the Inductively Coupled Argon Plasma (ICAP) method for chromium, and the Furnace Atomic Absorbtion (FAA) method for arsenic and lead.

6.1.4 IDENTIFY DATA QUANTITY NEEDS: RI PHASE IIA - GROUND WATER INVESTIGATION

The factors influencing the choice of monitoring well locations are the size and shape of the soil gas plume (primary factors), schedule, and budget (secondary factors). The plume determined by soil gas sampling is shown in Figure 5-8.

Wells must be installed to answer specific questions concerning the distribution of contaminants in the ground water. Three wells will be installed in addition to the two existing wells on site. For this example site, five wells will be adequate to: (1) confirm sources, (2) confirm the extent of the soil gas plume, and (3) determine the magnitude of contamination within known plumes. The locations of these monitoring wells are shown on Figure 6-1.

To determine the extent of the ground water contamination plume, wells MW1 and MW2 will be installed at locations shown in Figure 6-1. These well locations are beyond the edge of the soil gas plume and hence should encounter uncontaminated ground water. These wells provide early warning by indicating if contaminants are moving closer to the private water supply wells. Well MW3 and existing well OW1 are located within the soil gas plume to indicate the magnitude of ground water contamination. Only one new well is required for this purpose and will provide a measure of the range of contaminants present in the plume. To determine background water quality, existing well OW2 will be sampled.

After the results from these wells are obtained, an assessment of the data will be made and any data gaps will be indicated. Additional wells will be added if necessary to fill data gaps.

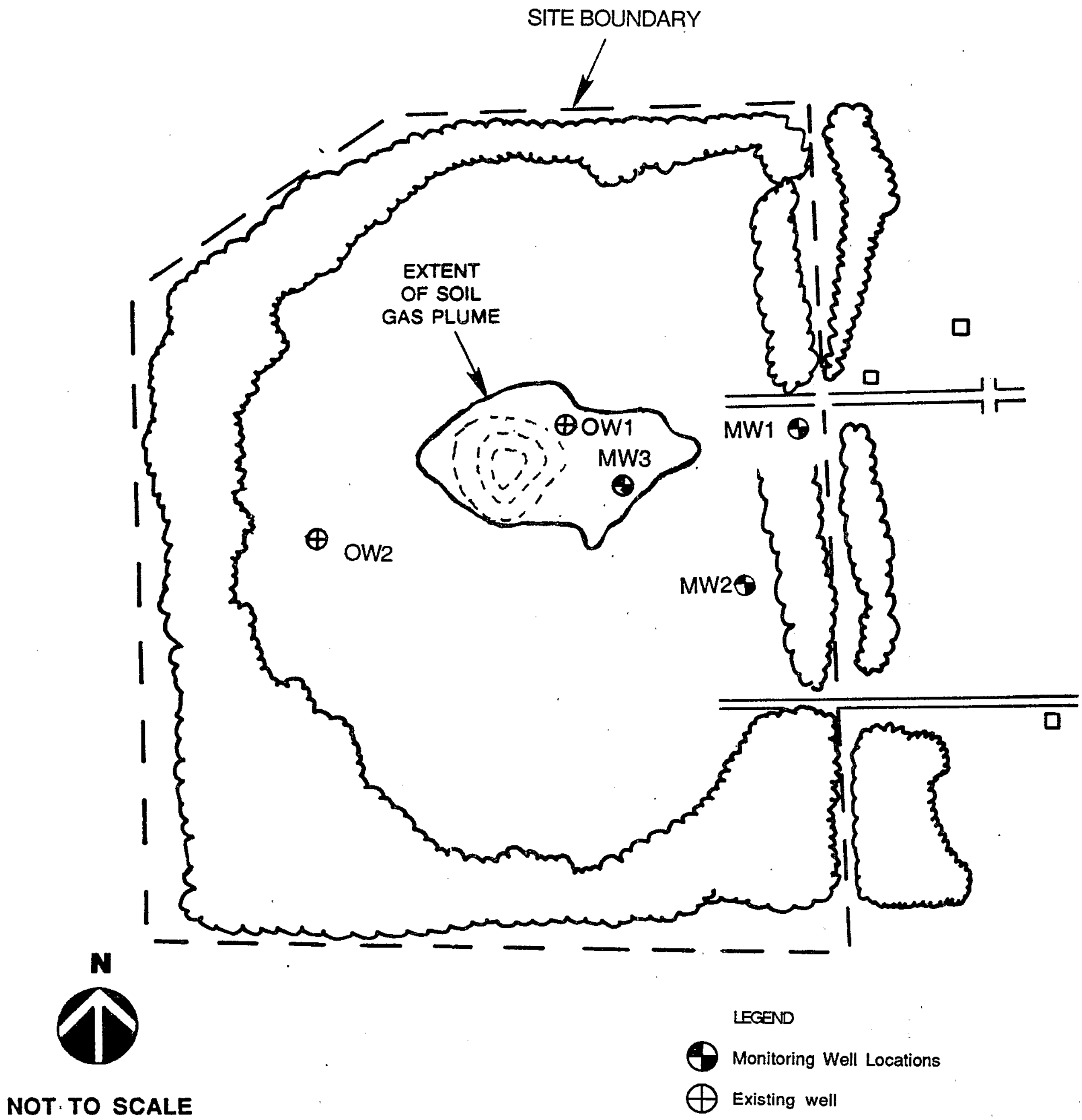

FIGURE 6-1
LOCATION OF MONITORING WELLS

6.1.5 EVALUATE SAMPLING/ANALYSIS OPTIONS: RI PHASE I GROUND WATER INVESTIGATION

The installation of monitoring wells will be undertaken by use of a drill rig equipped with a hollow stem auger. This drill rig will also be used to obtain soil samples at the site. Ground water and soil samples will be collected at thte locations specified previously following standard operation procedures.

The DQO process for Phase IIA is summarized in Table 6-2.

6.1.6 REVIEW PARCC PARAMETERS: RI PHASE IIA - GROUND WATER INVESTIGATION

Ground water samples from the early warning wells (MW1, MW2) will be analyzed for volatile organics using Method 601/602. Ground water samples from the other wells will be analyzed for volatiles using Method 624. All well samples will be analyzed for metals using CLP RAS procedures. PARCC parameters are reviewed separately below for wells MW1 and MW2, and for the other wells.

<u>PARCC Parameters for Wells MW1 and MW2</u>

<u>Precision</u>

Precision data on Method 601/602 for volatile organics are not readily available. Replicate samples will be collected and analyzed to estimate the precision actually achieved on volatile organics analysis. Historical precision data for CLP RAS metals analysis are listed below:

Contaminant	Precision (% RSD)
Lead	32
Arsenic	9.4
Chromium	9.8

<u>Accuracy</u> - Historical accuracy data for analysis of volatile organic compounds by Method 601/602 are not readily available. Matrix spike samples will be analyzed to determine the accuracy achieved on these samples. Historical accuracy data for the metals analyses using CLP RAS procedures are listed below:

Contaminant	Accuracy (% Bias)
Lead	-0.7
Chromium	-2.6
Arsenic	-8.3

<u>Representativeness</u> - Three to five well volumes will be purged before sampling the observation wells to ensure that standing water is removed and that the samples are representative of the ground water.

<u>Completeness</u> - These samples have been defined as critical samples; therefore, 100 percent completeness is required. If valid results are not obtained for any sample, a new sample aliquot will be analyzed or the well will be resampled.

<u>Comparability</u> - The use of standard, published sampling and analytical method will ensure the comparability of the data.

<u>PARCC PARAMETERS FOR WELL MW3, OW1 AND OW2</u>

<u>Precision</u> - The CLP RAS historical precision data for the intended analytes are outlined below:

TABLE 6-2
DQO SUMMARY FORM

1. SITE

NAME DQO DEMONSTRATION
LOCATION ____
NUMBER ____

EPA REGION ____

PHASE ____
RI 1 RI 2 RI 3 ERA FS RD RA
(CIRCLE ONE)

2. MEDIA *(CIRCLE ONE)*	SOIL	GW	SW/SED	AIR	BIO	OTHER ____

3. USE *(CIRCLE ALL THAT APPLY)*	SITE CHARAC. (H&S)	RISK ASSESS.	EVAL. ALTS.	ENG'G DESIGN	PRP DETER.	MONITORING REMEDIAL ACTION	OTHER ____

4. OBJECTIVE GROUNDWATER DATA ARE REQUIRED TO EVALUATE THE EXTENT OF CONTAMINATION, DEVELOP A RISK ASSESSMENT, AND ASSESS POTENTIAL REMEDIAL ALTERNATIVES

5. SITE INFORMATION

AREA 200ft x 200ft DEPRESSION DEPTH TO GROUND WATER 15 feet
GROUND WATER USE DRINKING WATER
SOIL TYPES GLACIAL TILL - DEPTH 0-30 ft; SHALE - DEPTH 30->100 ft
SENSITIVE RECEPTORS RESIDENTS 1 MILE EAST OF THE SITE

6. DATA TYPES *(CIRCLE APPROPRIATE DATA TYPES)*

A. ANALYTICAL DATA

pH	PESTICIDES	TOX
CONDUCTIVITY	PCB	TOC
VOA	METALS	BTX
ABN	CYANIDE	COD
TCLP	WATER QUALITY PARAMETERS	

B. PHYSICAL DATA

PERMEABILITY	HYDRAULIC HEAD
POROSITY	PENETRATION TEST
GRAIN SIZE	HARDNESS
BULK DENSITY	____
____	____

7. SAMPLING METHOD *(CIRCLE METHOD(S) TO BE USED)*

ENVIRONMENTAL	BIASED	GRAB	NON-INTRUSIVE	PHASED
SOURCE	GRID	COMPOSITE	INTRUSIVE	____

8. ANALYTICAL LEVELS *(INDICATE LEVEL(S) AND EQUIPMENT & METHODS)*

LEVEL 1 FIELD SCREENING - EQUIPMENT ____
LEVEL 2 FIELD ANALYSIS - EQUIPMENT ____
LEVEL 3 NON-CLP LABORATORY - METHODS ____
LEVEL 4 CLP/RAS - METHODS OW1, OW2, MW3, VOAs, METALS - MW1, MW2 METAL
LEVEL NS NON STANDARD MW1, MW2 VOAs METHOD 601/602

9. SAMPLING PROCEDURES

BACKGROUND - 2 PER EVENT OR WELL OW2
CRITICAL (LIST) ____
PROCEDURES STANDARD WELL INSTALLATION SOPs

10. QUALITY CONTROL SAMPLES *(CONFIRM OR SET STANDARD)*

A. FIELD
COLLOCATED - 5% OR ____
REPLICATE - 5% OR ____
FIELD BLANK - 5% OR ____
TRIP BLANK - 1 PER DAY OR ____

B. LABORATORY
REAGENT BLANK - 1 PER ANALYSIS BATCH OR ____
REPLICATE - 1 PER ANALYSIS BATCH OR ____
MATRIX SPIKE - 1 PER ANALYSIS BATCH OR ____
OTHER ____

11. BUDGET REQUIREMENTS

BUDGET $18,000 SCHEDULE 3 WEEKS
STAFF Hydrogeologist, Drillers, Chemist

CONTRACTOR ____ **PRIME CONTRACTOR** ____
SITE MANAGER ____ **DATE** ____

FOR DETAILS SEE SAMPLING & ANALYSIS PLAN

CDM SF DQO 1.002

Contaminant	Precision (% RSD)
TCE	17
PCE	13
Benzene	12
Toluene	14
Lead	32
Arsenic	9.4
Chromium	9.8

QC samples will be analyzed to determine the precision achieved on the well samples.

Accuracy - The CLP RAS historical accuracy for the intended analytes are:

Contaminant	Accuracy (% Bias)
TCE	-22.8
PCE	-42.5
Benzene	-3.3
Toluene	-23.3
Lead	-0.7
Arsenic	-8.3
Chromium	-2.6

Representativeness - Three to five well volumes of water will be purged to ensure that well samples are representative of the ground water quality near the well.

Completeness - The historical completeness achieved for CLP RAS analyses is 80-85 percent. This completeness range is acceptable given the project goals. However, if validated results are not obtained for each well sample, the well will be resampled.

Comparability - The use of standard published sampling and analytical methods will ensure data comparability.

6.2 DQO STAGE 2 - IDENTIFY DATA USES AND NEEDS: PHASE IIB - SUBSURFACE SOILS INVESTIGATION

Soil sampling in Phase I of the RI provided information on the nature, extent, and magnitude of surface metals contamination. In Phase I only surface soil samples were obtained so the concentrations of metals and, more importantly, volatile organics are not known at depth.

The purpose of this phase of the RI is to obtain information on the nature, extent, and magnitude of volatile and heavy metal contamination at depth.

Soil contamination is a major concern at the site and adequate data must be obtained to allow for an accurate estimate of the areal extent and total volume of contaminated soil present. This information must be determined for detailed cost estimates to be developed.

6.2.1 IDENTIFY DATA USES: RI PHASE IIB - SUBSURFACE SOIL INVESTIGATION

Soil sampling data will be used to assess the magnitude and distribution of subsurface soil contamination. This information will be used in a risk assessment, in evaluating remedial alternatives, and in designing a remedial action. Soil sampling will also provide information on the physical properties of the soils which can be used in assessing remedial alternatives.

6.2.2 IDENTIFY DATA TYPES: RI PHASE IIB - SUBSURFACE SOIL INVESTIGATION

The types of data to be collected are concentrations of volatile organics and metals in the soils and the porosity and permeability (horizontal and vertical) of the soil.

6.2.3 IDENTIFY DATA QUALITY NEEDS: RI PHASE IIB - SUBSURFACE SOIL INVESTIGATION

Daily Quality Factors

Prioritized Data Uses:	Risk Assessment Evaluation of Alternatives Engineering Design
Appropriate Analytical Levels:	Risk Assessment: Levels III, IV, V Evaluation of Alternatives: Levels II, III, IV Engineering Design: Levels II, III, IV
Primary Contaminants of Concern:	TCE, Arsenic, Chromium, Lead
Levels of Concern:	TCE: 4 - 40 mg/kg As: 25 - 35 mg/kg Cr: 90 - 110 mg/kg Pb: 450 - 550 mg/kg
Required Detection Limit:	TCE: 2 mg/kg (Given the high cleanup level anticipated for the metals, detection limits in the low mg/kg range will be acceptable.)
Critical Samples:	Clean samples at boundaries of contaminated area.

The level of concern for soil TCE concentration shown above (4 mg/kg) is actually the lowest value from a range of potential levels of concern (4 to 40 mg/kg). This range of values was obtained by applying a simple transport model which predicts the concentration of TCE in the soil which will result in TCE concentrations at the drinking water wells which exceed 5 ppb (proposed MCL). Inputs to this process include soil organic carbon content, TCE solubility, net inflow, permeability, dispersion, retardation, biodegradation, and hydraulic gradient. Uncertainty in these values causes the large range in the possible levels of concern. After completion of the RI, the level of concern for soil TCE will be refined and an action level will be chosen. The level of concern is presented here only to ensure that an analytical technique with appropriate detection limits is selected.

To assess remedial alternatives and provide input into a risk assessment, quantitative data concerning the magnitude, nature and distribution of contaminants are required. Metals are not expected to migrate downward from the surface to any great extent due to the relatively high pH of the soils and waste material. As such, metals are not expected to impact ground water resources, or cause a human health concern via this pathway. For this reason Level II data (X-Met) will be sufficient for metals analyses.

Volatile organic contaminants are expected to be present in significant quantities at depth. Potentially, analytical methods from Levels II, III or IV could be used. The proposed methods from each analytical level are shown below:

Level	Method
II	Head Space/GC/PID
III	Purge & Trap/GC/MS
IV	CLP RAS (purge & trap/GC/MS)

Level III and IV data provide quantitative information on the concentration of organics in the soil. The general level of the expected accuracy and precision of these methods is available from historical performance data (see Appendix A).

Level II analyses (field GC) can be used to obtain numerical concentration values for a small set (5) of important VOA compounds. The precision and accuracy values for this procedure are unknown.

6.2.4 IDENTIFY DATA QUANTITY NEEDS: RI PHASE IIB - SUBSURFACE SOIL INVESTIGATION

Sufficient data must be collected to define the vertical and horizontal extent of the contaminants. This objective can be cost effectively accomplished by sampling according to a regular three-dimensional grid. The chosen grid size will directly influence the number of samples taken.

Based on previous site investigations and the conceptual model, the depth to ground water is 15 ft. No information concerning the variation in contaminants with depth is available. Thus, the choice of the vertical distance between samples must be based on assumed variation in contaminant concentration with depth and the goals of the study.

The goal of this phase is to determine the horizontal and vertical extent of contaminants. Any available or assumed information on these quantities will aid in choosing the necessary grid size.

The horizontal extent of contaminants is expected to increase with depth due to the dispersion of the contaminants during downward migration. For this reason, dispersion within the unsaturated zone should be greatest at the water table, so one sample must be taken at or just above the water table. Samples at the water table become critical samples near the boundaries of contamination. In addition to the samples taken at the water table, one sample at a depth of 7-9 ft will be taken from each boring. The information obtained from this sample will be used in conjunction with the information from the deeper samples to assess any vertical trends in contaminant levels and to determine the total quantity of organic contaminants in the soil. Based on the above rationale, two samples (at depths of 13-15 and 7-9 ft) will be taken from each soil boring.

A major factor influencing the choice of horizontal grid spacing is the maximum likely horizontal extent of soil contamination. This information will indicate the areal coverage required for the soil samples. Given the 200 ft square surface contamination area and a 15 ft depth to the water table, vadose zone contamination is expected to be contained within a 300 ft square area which includes the depressed area. This is only a preliminary estimate of the area of contamination which may be modified based on initial Level II soil analyses.

The horizontal grid size chosen is based on the assumed spatial variability of the contaminants. Information on the spatial variability of organic contaminants is not available for samples taken at depth; however, information on surface metals contamination is available (see Section 5.5.3). Although inorganic contaminants do not behave identically to organic contaminants in the subsurface environment, both the organic and inorganic contaminants have an identical site genesis. For this reason, the spatial variability of the organic contaminants will be assumed to be similar to that of inorganic contaminants. This assumption suggests a process for setting the horizontal grid size.

In Appendix C of the Development Process manual, the relationship between spatial variability and the representivity of the grid size is discussed, and it is shown that representivity of samples is linked to the range of correlation of the variogram model. Ideally, samples should be taken on a grid which is approximately one half of the range of correlation. A geostatistical analysis of surface soil lead concentration (Section 5.5.3.2) indicates that the range of correlation for lead surface contamination is 75 ft. Based on this analysis, a representative grid size would be 40 ft, assuming lead and organic contaminants behave identically. However, since organic contaminants do not behave identically to lead, a slightly larger grid is chosen to avoid oversampling. A 50-ft grid will provide the required sampling density.

Based on the previous analysis, 36 soil borings will be installed and sampled at two depths for a total of 72 samples over a 300-ft-by-300-ft area. The selected grid is shown in Figure 6-2. The number of samples chosen for this phase is slightly less than the number of samples estimated during the project scoping and included in the work plan (100). The reduction in sample requirement is a result of information gathered in Phase IC.

The choice of the sampling grid spacing and sampling depths was based on the assumed spatial distribution of the organic contaminants. Phase IC of the RI identified surface soil metal contamination within the 0-2 in. depth interval. Soil sampling will be performed, in this phase, to investigate the vertical extent of metal contamination.

Metal contamination is considered separately from organic contamination because the vertical distribution of these two types of contaminants are expected to be very different. The sludges containing the metals were relatively caustic so metals are expected to be immobile.

For this reason, the downward migration of metals, will be limited. Based on this model of the vertical distribution of metals the vertical grid spacing must be denser for the metals than for the organics.

Based on the conceptual model of metals migration and experience at other sites, the maximum depth of migration is estimated to be 3 ft. Based on this assumed depth of migration samples will be taken at 6-in. depth intervals. To ensure that these samples are representative of the contamination at depth over the most highly contaminated portion of the depressed area, four of the soil borings (see Figure 6-2) located within this zone will be sampled at 6-in. intervals from the surface to a depth of 3 ft.

This sampling procedure yields 24 soil samples which will be analyzed on-site for arsenic lead, and chromium content using the X-Met. If on-site analysis indicates that metals contamination extends below a depth of 3 ft, additional samples will be taken until 1 ft of soil with no detectable metals concentrations is located.

6.2.5 EVALUATE SAMPLING/ANALYSIS OPTIONS: RI PHASE IIB - SUBSURFACE SOIL INVESTIGATIONS

The turnaround times, analysis costs, precision and accuracy vary with the chosen level of the analytical method. Each of the analytical methods has its strengths. A comparison of the methods is given below:

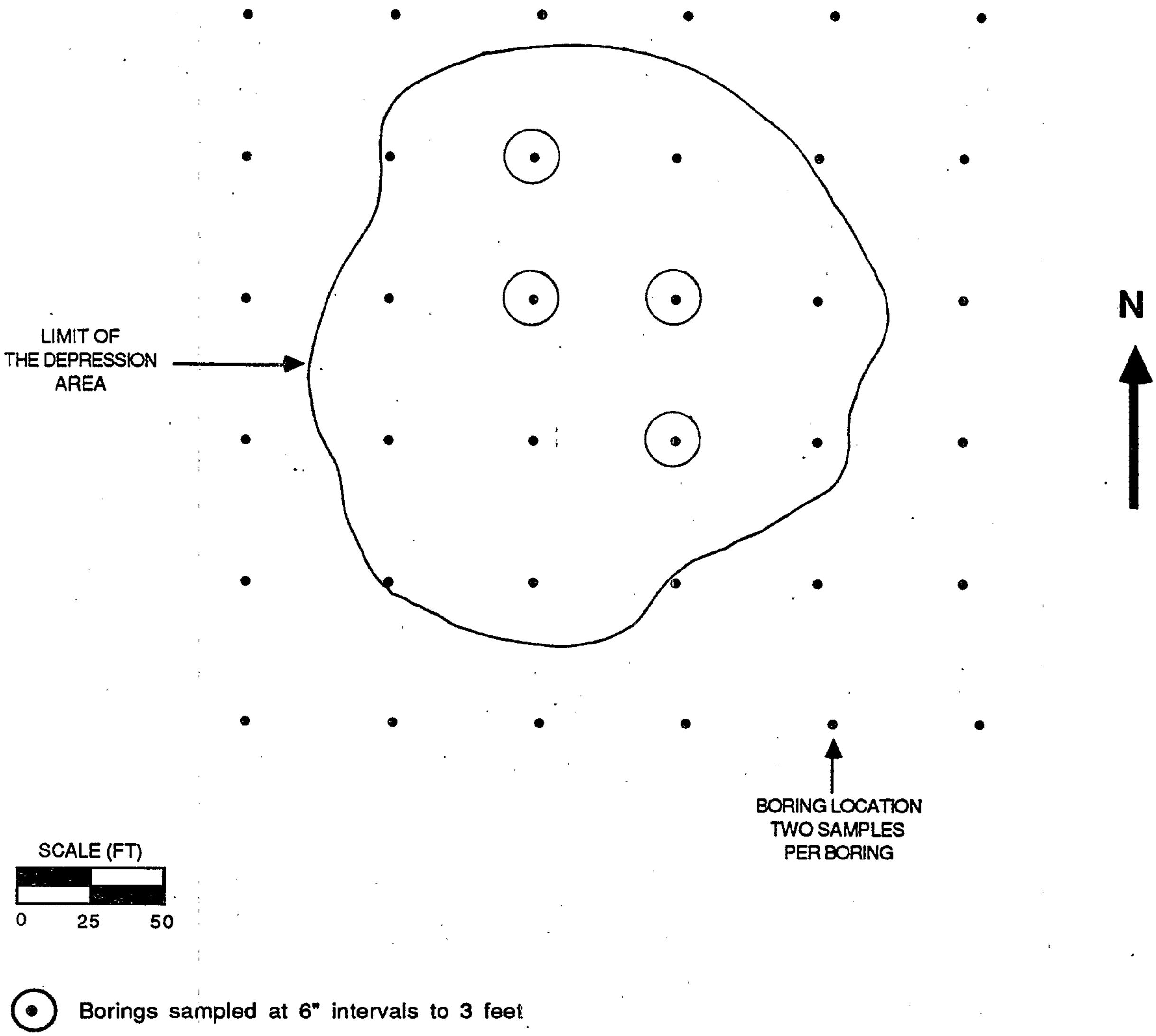

FIGURE 6-2
SOIL SAMPLING LOCATIONS

Level	Turnaround Time	Cost of Analysis	Precision & Accuracy
II	10 minutes to 2 hrs.	$ 40	Low
III	1 day to 1 week	$300	High
IV	6 weeks	$ 80[1]	High

[1] Labor associated with sample shipment. Does not include laboratory costs.

Based on the above table, the primary drawback of Level II data is the low accuracy and precision of the method. The low quality of these data is offset by the fast turnaround and low cost of the analyses. These factors suggest that Level II data should be used for screening and Level III or IV data should be used for confirmation or to adjust the Level II analyses.

The proposed sampling plan contains 72 samples located on 2 vertical levels. All 72 samples will be analyzed on-site using Level II analytical procedures. A subset of these samples will be sent to the CLP for confirmatory analysis. These confirmatory samples will be analyzed for volatile organics only, because the Level II metals analyses (X-Met) were confirmed during the surface sampling phase of the RI.

Confirmation of Level II organic analyses is of greatest importance when the reported concentration is near the level of concern. To accurately assess the performance of the Level II method near the level of concern, at least six samples with measured TCE concentrations near the level of concern range will be sent to the CLP. Six samples were chosen to provide an accurate estimate of the potential errors of the Level II procedure at the level of concern.

In addition to the previous 6 confirmation samples, at least 12 more confirmation samples are required to assess the effectiveness of the field GC over the likely range of concentration. To ensure that the field GC is not reporting false negatives, four samples containing no detectable organics will be sent to the lab. Also, eight of the samples with reported concentrations which are larger than the action level range will be sent to the lab. This set of 18 confirmatory samples (25 percent of the total) will provide information on the effectiveness of the field GC over the range of concentrations which are encountered.

The DQO process for Phase IIB is summarized in Table 6-3.

6.2.6 REVIEW PARCC PARAMETERS: RI PHASE IIB - SUBSURFACE SOIL INVESTIGATIONS

The achievable precision and accuracy of Level II methods are unknown. For CLP RAS confirmatory samples the following information is available.

Precision - The CLP RAS historical precision for analysis of soils for TCE is unavailable. QC samples will be analyzed to determine the precision achieved. However, historical precision for similar organic compounds ranges from 10 to 30 percent RSD (see Appendix A).

Accuracy - The CLP RAS historical accuracy for analysis of soils for TCE is unavailable. However, historical accuracy for similar organic compounds ranges from -12 to +13 percent bias. QC samples will be analyzed to determine the accuracy achieved (see Appendix A).

TABLE 6-3
DQO SUMMARY FORM

1. SITE

NAME DQO DEMONSTRATION
LOCATION
NUMBER

EPA REGION
PHASE
RI 1 RI 2 RI 3 ERA FS RD RA
(CIRCLE ONE)

2. MEDIA *(CIRCLE ONE)*	SOIL	GW	SW/SED	AIR	BIO	OTHER

3. USE *(CIRCLE ALL THAT APPLY)*	SITE CHARAC. (H&S)	RISK ASSESS.	EVAL. ALTS.	ENGG DESIGN	PRP DETER.	MONITORING REMEDIAL ACTION	OTHER

4. OBJECTIVE SOIL SAMPLES WILL BE TAKEN AND ANALYZED FOR VOAs AND METALS TO DETERMINE THE HORIZONTAL AND VERTICAL EXTENT OF CONTAMINATION

5. SITE INFORMATION

AREA 200 ft X 200 ft DEPRESSION DEPTH TO GROUND WATER 15 feet
GROUND WATER USE DRINKING WATER
SOIL TYPES GLACIAL TILL - DEPTH 0-30 ft; SHALE - DEPTH 30->100 ft
SENSITIVE RECEPTORS RESIDENTS 1 MILE EAST OF SITE

6. DATA TYPES *(CIRCLE APPROPRIATE DATA TYPES)*

A. ANALYTICAL DATA

pH	PESTICIDES	TOX
CONDUCTIVITY	PCB	TOC
VOA	METALS	BTX
ABN	CYANIDE	COD
TCLP		

B. PHYSICAL DATA

PERMEABILITY	HYDRAULIC HEAD
POROSITY	PENETRATION TEST
GRAIN SIZE	HARDNESS
BULK DENSITY	

7. SAMPLING METHOD *(CIRCLE METHOD(S) TO BE USED)*

ENVIRONMENTAL BIASED GRAB NON-INTRUSIVE PHASED
SOURCE GRID COMPOSITE INTRUSIVE

8. ANALYTICAL LEVELS *(INDICATE LEVEL(S) AND EQUIPMENT & METHODS)*

LEVEL 1 FIELD SCREENING - EQUIPMENT
LEVEL 2 FIELD ANALYSIS - EQUIPMENT METALS - XMET, VOAs GC
LEVEL 3 NON-CLP LABORATORY - METHODS
LEVEL 4 CLP/RAS - METHODS CONFIRMATION OF VOAs
LEVEL NS NON STANDARD

9. SAMPLING PROCEDURES

BACKGROUND - 2 PER EVENT OR 3 SAMPLES
CRITICAL (LIST) TWO CLEAN SAMPLES IN EACH DIRECTION
PROCEDURES SPLIT SPOON SAMPLING

10. QUALITY CONTROL SAMPLES *(CONFIRM OR SET STANDARD)*

A. FIELD
COLLOCATED 5% OR
REPLICATE - 5% OR
FIELD BLANK 5% OR
TRIP BLANK 1 PER DAY OR

B. LABORATORY
REAGENT BLANK - 1 PER ANALYSIS BATCH OR
REPLICATE - 1 PER ANALYSIS BATCH OR
MATRIX SPIKE - 1 PER ANALYSIS BATCH OR
OTHER

11. BUDGET REQUIREMENTS

BUDGET $20,000 SCHEDULE 4 WEEKS
STAFF GEOLOGIST, CHEMIST, DRILLERS

CONTRACTOR **PRIME CONTRACTOR**
SITE MANAGER **DATE**

FOR DETAILS SEE SAMPLING & ANALYSIS PLAN CDM SF DQO 1.002

Representativeness - A sampling grid has been defined to ensure representativeness of the soil samples.

Completeness - The RAS CLP historical completeness is approximately 80-85 percent. If valid analytical results are not obtained for the clean samples, a new sample aliquot will be analyzed.

Comparability - The use of standard soil sampling procedures and recognized field and laboratory techniques should make the resulting data comparable with other similiar measurements on similiar samples.

6.3 DQO STAGE 3 - DESIGN DATA COLLECTION PROGRAM: PHASE II REMEDIAL INVESTIGATION

As the data collection documentation (i.e., the work plan, S&A plan and QAPjP) was developed prior to the initiation of Phase I, the discussion at this point will focus on Phase II elements. Whereas the work plan completed at the start of the RI generally discussed the anticipated Phase II tasks, the S&A plan was specific for Phase I elements. The development of the S&A plan for Phase II is undertaken following evaluation of Phase I data.

6.3.1 ASSEMBLE DATA COLLECTION COMPONENTS: PHASE II REMEDIAL INVESTIGATIONS

The S&A plan developed for Phase II will account for all sampling tasks and phases. Table 6-4 provides a summary of Phase II data collection components for the example site. The schedule for these activities is shown in Figure 6-3.

6.3.2 DEVELOP DATA COLLECTION DOCUMENTATION: PHASE II REMEDIAL INVESTIGATION

For Phase II of the RI, S&A components will be prepared for each individual activity including:

- New well installation and sampling
- Soils sampling

The detailed information to be provided is similar to that discussed for Phase I elements and will not be repeated here.

6.4 DQO STAGE 1 - COLLECT AND EVALUATE DATA: PHASE II REMEDIAL INVESTIGATIONS

This section presents a general review of the data collected during Phase II of the RI. In addition, these results will be taken together with Phase I results to form an overall evaluation of the site.

6.4.1 ANALYSIS OF RESULTS: RI PHASE IIA - GROUND WATER INVESTIGATIONS

Five wells were sampled and analyzed for volatile organics and metals during Phase II. The well locations are shown in Figure 6-1. The results obtained are shown below:

TABLE 6-4
DATA COLLECTION COMPONENTS - PHASE II

SAMPLE RI PHASE	MEDIA	TYPE	NUMBER OF SAMPLES	QA/QC SAMPLES
2A	GROUND WATER	GRAB	5	1 DUPLICATE 1 SPIKE
2B	SOIL	AUGER	72 (ORGANICS) 24 (METALS)	18

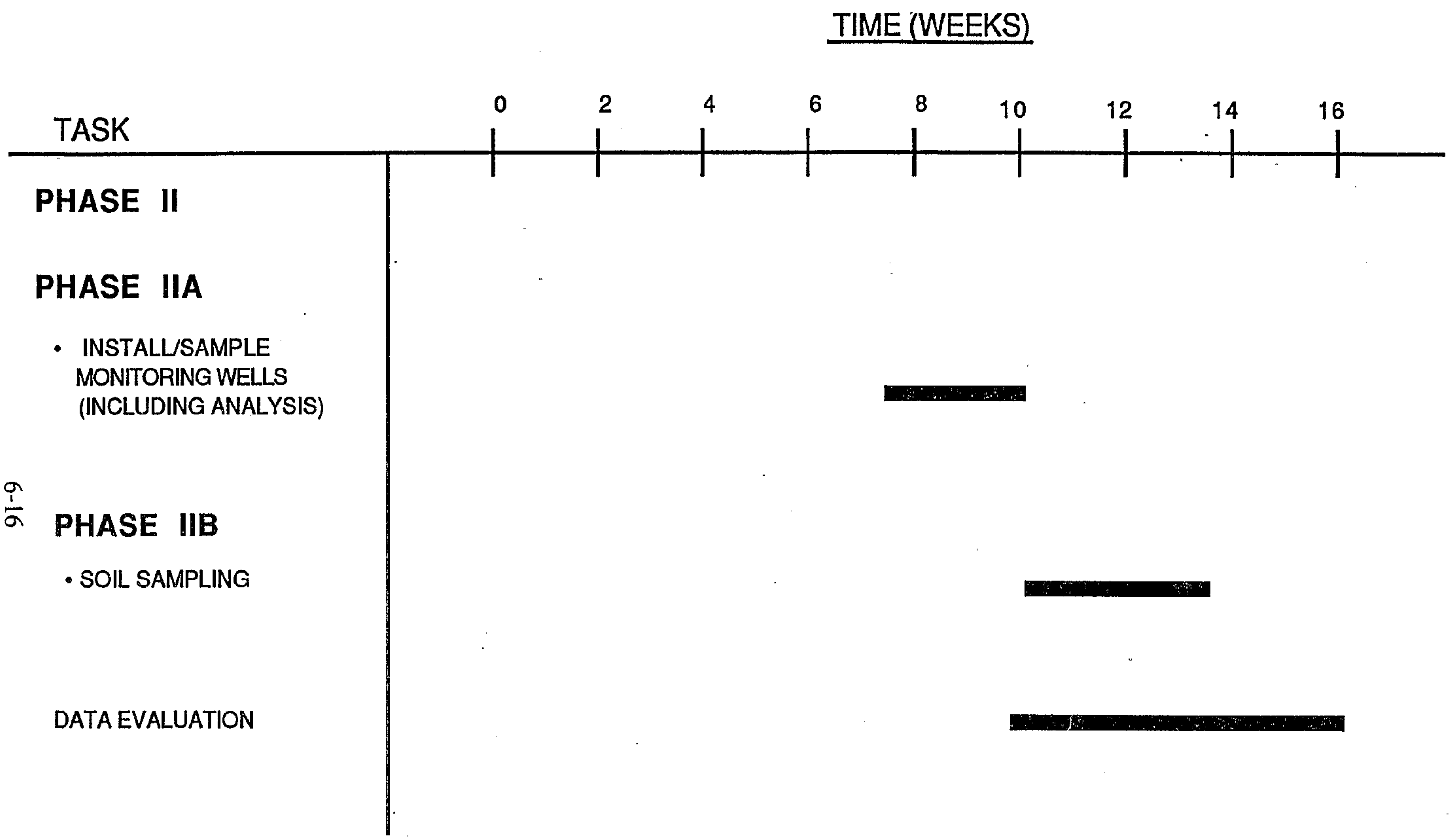

FIGURE 6-3
PHASE II REMEDIAL INVESTIGATION SCHEDULE

Well	Metals	Volatile Organics
OW1	ND	TCE - 62 ug/l
OW2	ND	ND
MW1	ND	ND
MW2	ND	ND
MW3	ND	TCE - 47 ug/l

ND - under metals indicates no significant concentrations detected.
ND - under volatile organics indicates not detected above method detection limit

In wells OW1 and MW3 volatiles other than TCE were not detected.

No volatile contaminants were detected in monitoring wells MW1 or MW2 so these wells will be used to warn of the encroachment of volatile organics toward the residential wells. These two wells also mark the eastern extent of the ground water plume. Finally, these wells verify that soil gas correctly indicates the extent of the ground water plume. Thus, the north, south and western limits of the ground water plume can be extrapolated from the measured soil gas plume.

Wells OW1 and MW3 are located within the soil gas plume. These two wells show a small difference in TCE concentration. The observed difference in TCE concentration between these two wells (15 ug/l) can be attributed to analytical error. Based on the small difference observed between these concentrations, there is no indication that TCE varies erratically within the plume.

Well OW1 has been sampled by the FIT team and twice during this investigation. The analyses obtained for well OW1 are:

Sample #	Obtained During	TCE Concentration (ppb)
1	FIT	52
2	RI Phase 1	68
3	RI Phase 2	62

These data suggest an increase in concentration over time. By examining the precision of the analytical method (EPA method 624) and comparing this value with the fluctuations in concentration observed in well OW1 it is possible to state whether the increase in concentration seen in well OW1 is significant.

The historical precision for method 624 is 17 percent RSD. The precision observed in the three samples from OW1 is calculated below.

The definition of percent RSD is:

$$\% \text{ RSD} = [2 \ |X_1 - X_2| \ / \ (X_1 + X_2)] \ (100/\sqrt{2})$$

Where X_1 is measurement #1 of a replicate

X_2 is measurement #2 of a replicate

For the three analyses from OW1 percent RSD is:

Sample #'s	%RSD
1, 2	18.8
2, 3	6.5
1, 3	12.4

The average of these three values is 12.6 percent. This value is less than the historical precision of the analytical method (17 percent). Since the observed variation in the samples from well OW1 is less than the expected variation in the analytical method, the observed increase in concentration in well OW1 over time may simply be due to analytical variability rather than an actual increase in TCE concentration in the well.

6.4.2 ANALYSIS OF RESULTS: RI PHASE IIB - SUBSURFACE SOIL SAMPLING RESULTS

Soil samples from the depth intervals 7-9 ft and 13-15 ft were obtained from 36 boreholes. In addition, the four boreholes identified in Figure 6-2 were sampled at 6-in. intervals to a depth of 3 ft. The results obtained are summarized below for lead and TCE. The results for other contaminants of concern are analogous and, for sake of brevity, will not be discussed here.

MEAN CONCENTRATION (mg/kg)

Depth (ft)	Lead	TCE
.5	432	NA
1.0	189	NA
1.5	67	NA
2.0	10	NA
2.5	ND	NA
3.0	ND	NA
8	ND	3.9
14	ND	.87

ND - No concentrations detected above background
NA - No analysis performed

The results indicate that lead has not migrated below a depth of 2 ft and the bulk of TCE contamination has not migrated to a depth of 14 ft. In the horizontal plane, TCE contamination is much more widespread at a depth of 8 ft than at a depth of 14 ft. Since contamination found at 8 ft will be of greater importance in the assessment of remedial alternatives, the discussion of results will center on the 8-ft depth interval. The data analysis procedures demonstrated on the data from the 8-ft depth interval are equally applicable on the data from the 14-ft depth interval.

The analyses of samples taken at a depth of 8 ft are shown in Figure 6-4. The contour line shown on this figure is the best estimate of the line separating soil containing less than and greater than 4 mg/kg TCE. Due to analytical and sampling errors and the intrinsic variability of the contaminants, the exact location of this line is uncertain. Uncertainty in the location of this line indicates that there is

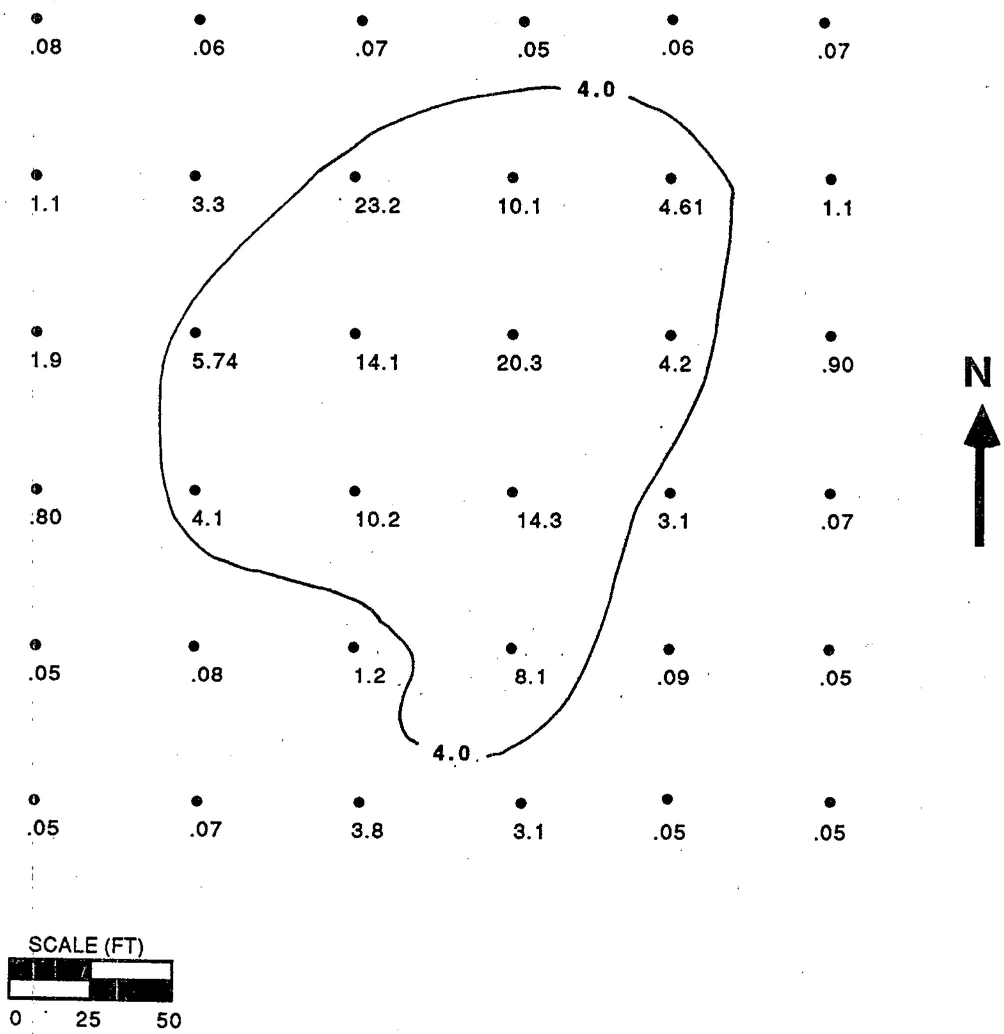

FIGURE 6-4
SOIL SAMPLING RESULTS (DEPTH 8 FEET) AND KRIGED CONTOUR LINE (4ppm)

some chance that material located outside the 4 ppm TCE contour line (and therefore assumed to contain less than 4 ppm TCE) might, in fact, contain more than 4 mg/kg TCE.

To assess the likelihood that soil which is assumed to contain less than 4 mg/kg actually contains more than 4 mg/kg advanced geostatistical methods can be used (see Appendix A of the Development Process document). This procedure directly determines the probability that soil at a particular location exceeds 4 ppm. This probability value is based on all measured site specific uncertainties and quantifies the total uncertainty surrounding a particular measurement. These probability values provide valuable information for assessing the volume of material which must be removed from a site.

Using advanced kriging, the probability that TCE concentration exceeds 4 ppm at each location within the depressed area can be determined. Once determined these probability levels can be contoured. One such contour corresponding to a 15 percent chance of exceeding 4 ppm is shown in Figure 6-5. Soil within this contour line has greater than a 15 percent chance of exceeding 4 ppm TCE while soil outside this of contour line has less than a 15 percent of exceeding 4 ppm. Thus, if soil is removed to the 15 percent probability contour line, the remaining soil has, at most, a 15 percent chance of containing more than 4 ppm TCE.

The previous statistical analysis provides a measure of uncertainty surrounding the volume of material which should be removed as part of a remedial action. This uncertainty is represented in Figure 6-5 by the distance between the 4 ppm contour line and the 15 percent probability of exceeding the 4 ppm line. Based on the uncertainty represented in such a figure, the decision maker can assess whether the available data are sufficient to reach a decision. If the data are insufficient to reach a decision, an uncertainty contour map can be used to indicate the area of greatest uncertainty and can define the location of samples which must be taken during the remedial design phase to reduce uncertainty to an acceptable level. In this example, any additional samples would be located between the 4 ppm and 15 percent probability lines since samples in this area would produce the greatest reduction in uncertainty.

The uncertainty represented by the distance between the 15 percent contour line and the 4 ppm contour line is qualitative, however, it can be converted into a quantitative volumetric uncertainty. In Figure 6-5 a single probability line (15 percent) is shown. There are however a family of probability lines corresponding to 25 percent, 35 percent, 45 percent etc. probability of exceeding 4 ppm. If all of these contours were plotted, the volume between the 35 and 45 percent contour lines has, on average, a 40 percent chance of exceeding 4 ppm. Thus, 40 percent of the volume between these contour lines can be expected to exceed 4 ppm.

6.5 EXTENSION OF THE DQO PROCESS TO THE REMEDIAL DESIGN (RD) AND REMEDIAL ACTION (RA) OF UNCONTROLLED HAZARDOUS WASTE REMEDIAL RESPONSEACTIVITIES

At the conclusion of the RI/FS and after the preparation of the Record of Decision by EPA, the design phase at the site would commence. At this stage in the analysis the planned remediation for the site has been selected, costs have been estimated and design has started to a limited degree. During the RD/RA phase the preliminary design and cost estimates prepared during the RI/FS will be refined which will allow the design contractor to effectively implement the proposed remedy.

To plan the required work involved with the RA phases of work at the site, the DQO process will be used to (1) identify data gaps that may exist (2) plan additional sampling activities, and (3) collect the appropriate level of data needed to design and implement the selected remedy.

The DQO process that will be used during the RD/RA phase of work will be essentially identical to the process described for the RI/FS evaluation. The only difference in the execution of the RD/RA DQO will be in setting the objectives for these phases.

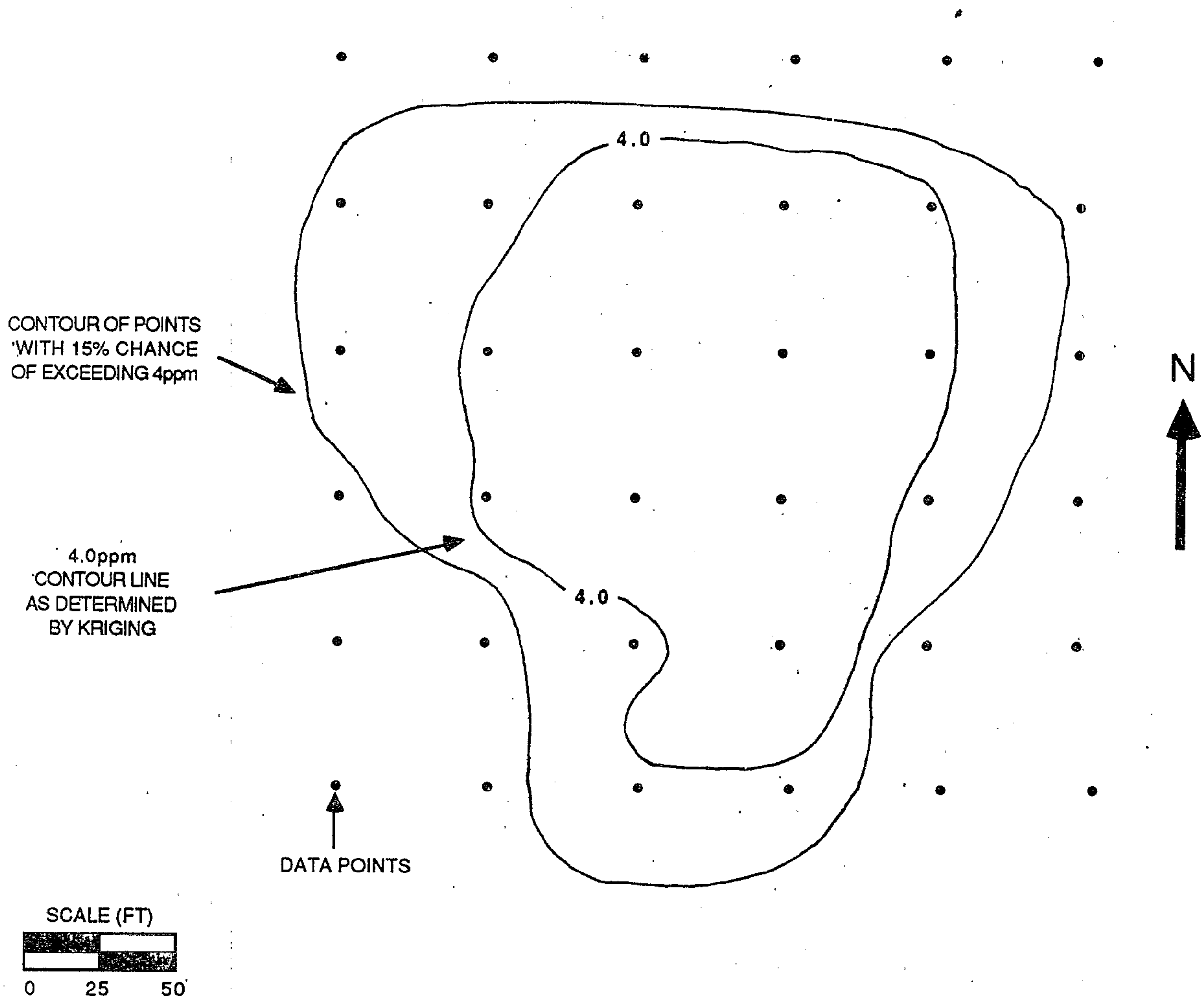

FIGURE 6-5
KRIGED PROBABILITY CONTOURS

A critical part of the design development of remedial measure would include defining the operating and monitoring parameters to insure that: (1) the full extent of the media contaminated will be treated, (2) the remediation performs in accordance with design specifications; and (3) the remediation is not resulting in the release of contaminants into the environment. The contract documents, plans and specifications, will have to define, through the use of the DQO process, the methods, equipment, action levels and detection limits to monitor the extent of remediation required, the effectiveness of the remediation in terms of the cleanup of the affected media and the potential for the release of contaminants to the environment associated with the remediation.

The key part of the RD/RA DQO will be the evaluation of existing data. Since the data collection program for the RI/FS should consider the data needs of the RD/RA phase (at least in a general manner), at many sites the data collected during the RI/FS will of sufficient detail and quality to be used for the RD/RA. However, at the initiation of the RD/RA phases, the data requirements will be reviewed to insure that all design cost estimates can be developed to the accuracy required.

The analysis of the data obtained during this two-phased remedial investigation can be used to assess potential remedial alternatives and are sufficient to develop cost estimates which are within +50 percent and -30 percent of the actual cost of implementation. The process by which potential remedial alternatives are evaluated and a viable remedial action selected is beyond the scope of this document. However, the DQO process does continue beyond the RI/FS and into the remedial design and remedial action.

For example, if soil removal was chosen in the Record of Decision, one question of interest would be whether it is necessary or desirable to treat the zones of metals and organic contamination separately. Additional sampling might be required during the RD phase to lower the uncertainty surrounding the volume of metals or volatile organics which must be removed to a level consistent with the +15 percent and -10 percent cost uncertainty associated with the RD phase. The analysis of uncertainty, including the location and number of required additional samples, can be performed using geostatistical methods such as advanced kriging.

7

CONCLUSION

7.0 CONCLUSIONS

This example demonstrated the application of DQOs to an RI at a fictitious hazardous waste site. The use of DQOs required that the uses and needs for each data type be specified at the project outset and be consistent with project objectives. Once data uses were specified, the quality and quantity of data required were determined. The DQO process, incorporated with development of the S&A plan, QAPjP, and work plan, ensured that data of sufficient quality to meet project objectives were obtained.

The tangible results of applying DQOs appear in cost savings. Sampling costs are reduced by using the conceptual model as a guide in determining the number of samples required. The conceptual model is refined continually as information is gathered during an investigation. Thus, data quantity needs are also continually refined. The use of a sampling methodology which conforms with the conceptual model can significantly reduce the number of samples obtained.

Analytical costs are reduced when DQOs are applied since the chosen analytical method will be the least expensive option which meets all project objectives. An analysis of the possible analytical options together with specified data uses will ensure that appropriate data quality (as defined by the level of analyses) is obtained for each specified data use.

The DQO is not a separate deliverable. The analysis of sampling and analytical options provided in this example document will not appear explicitly in either the work plan or sampling and analysis plan. However, it is envisioned that the analysis presented in this example will occur during meetings and phone conversations between primary data users and the rationale behind the selection of a particular sampling and analysis option will appear in meeting minutes or internal memos which will become part of the project file. The result of the DQO process will be a well thought out sampling and analysis plan which details the chosen sampling and analysis option.

APPENDIX A

HISTORICAL PRECISION AND ACCURACY DATA CLASSIFIED BY MEDIA BY ANALYTICAL LEVEL

APPENDIX A CONTENTS

HISTORICAL PRECISION AND ACCURACY TABLES

INTRODUCTION

The data in this Appendix have been compiled to assist the reader in selecting an analytical method appropriate for each data use. The methods are classified by media and by analytical levels defined as follows:

- Level I - field screening or analysis using portable instruments. Results are often not compound specific and not quantitative but results are available in real-time.
- Level II - field analysis using more sophisticated portable analytical instruments; in some cases, the instruments may be set up in a mobile or onsite laboratory. There is a wide range in the quality of data that can be generated. Quality depends on the use of suitable calibration standards, reference materials, and sample preparation equipment; and the training of the operator. Results are available in real-time or several hours.
- Level III - all analyses performed in an offsite analytical laboratory using standard, documented procedures. The laboratory may or may not be a CLP laboratory.
- Level IV - CLP routine analytical services (RAS). All analyses are performed in an offsite CLP analytical laboratory following CLP protocols.

Precision and accuracy data are presented in tabular fashion. Footnotes to each table cite the sources of the data and the concentration or concentration range at which the precision and accuracy were determined. When no concentration is cited no concentration information was available in the source material.

Precision is a measure of the variability in repeated measurements of the same sample compared to the average value. Precision is reported as % Relative Standard Deviation (RSD). The lower the % RSD, the more precise the data.

RSD is calculated for a pair of replicates using the following formula:

$$\%RSD = [2\,|X_1 - X_2|/(X_1 + X_2)]\ (100/\sqrt{2})$$

where X_1 is measurement #1 of a replicate

X_2 is measurement #2 of a replicate

Accuracy is reported as % Bias; as % Bias approaches zero, accuracy increases. Bias is calculated by the following formula:

$$\%\ Bias = \frac{X-Y}{Y}\ (100)$$

where Y is the known concentration or true value

X is the reported concentration

Bias measures the systematic error within an analytical technique.

TABLE A-1-C: HISTORICAL PRECISION AND ACCURACY DATA/WATER [a]

LEVEL III ANALYTICAL TECHNIQUES - METHODS OTHER THAN CLP RAS METHODS

ANALYTES	METHOD (TECHNIQUE)	CONCENTRATION RANGE	PRECISION % RSD	ACCURACY % BIAS
BENZENE	624 (GC/MS)	11 ug/l	16	0
		480 ug/l	21	-16
	8240 (GC/MS)	5-100 ug/l	21	12
BROMODICHLOROMETHANE	624 (GC/MS)	8 ug/l	28	-8.8
		480 ug/l	18	-6.7
	501.1 (PURGE & TRAP GC/MS)	0.9 ug/l	66	0
		550 ug/l	34	-3.8
	501.2 (EXTRACTION GC/MS)	1.8 ug/l	61	33
		170 ug/l	23	-19
BROMOFORM	624 (GC/MS)	9 ug/l	32	-23
		400 ug/l	30	10
	501.1 (PURGE & TRAP GC/MS)	4.8 ug/l	44	-27
		550 ug/l	41	7.5
	501.2 (EXTRACTION GC/MS)	6 ug/l	14	-23
		170 ug/l	15	1.8

TABLE A-1-C: HISTORICAL PRECISION AND ACCURACY DATA/WATER [a]
(continued)

LEVEL III ANALYTICAL TECHNIQUES - METHODS OTHER THAN CLP RAS METHODS

ANALYTES	METHOD (TECHNIQUE)	CONCENTRATION RANGE	PRECISION % RSD	ACCURACY % BIAS
CHLOROFORM	624 (GC/MS)	4.5 ug/l	31	2.2
		300 ug/l	14	-0.6
	501.1 (PURGE & TRAP GC/MS)	0.9 ug/l	64	44
		550 ug/l	14	-0.02
	501.2 (EXTRACTION GC/MS)	1.8 ug/l	68	-39
		170 ug/l	26	-1.2
DIBROMOCHLOROMETHANE	624 (GC/MS)	8.1 ug/l	13	-3.1
		360 ug/l	19	10
	501.1 (PURGE & TRAP GC/MS)	0.8 ug/l	35	-12.5
		550 ug/l	36	4.7
	501.2 (EXTRACTION GC/MS)	1.8 ug/l	37	0
		170 ug/l	13	0.02
DIOXIN	613 (GC/MS)	21 ng/l	25	N.A.
		202 ng/l	21	N.A.

TABLE A-1-C: HISTORICAL PRECISION AND ACCURACY DATA/WATER [a]
(continued)

LEVEL III ANALYTICAL TECHNIQUES - METHODS OTHER THAN CLP RAS METHODS

ANALYTES	METHOD (TECHNIQUE)	CONCENTRATION RANGE	PRECISION % RSD	ACCURANCY % BIAS
METHYLENE CHLORIDE	624	7.2 ug/l	78	-17
	(GC/MS)	480 ug/l	52	-25
TOLUENE	624	13.5 ug/l	19	15
	(GC/MS)	600 ug/l	31	-14
	8240	25 ug/l	19	-10
	(GC/MS)	75 ug/l		
TRICHLOROETHENE	624	5.4 ug/l	48	44
	(GC/MS)	360 ug/l	39	-2.3
	8240	25 ug/l	24	5
	(GC/MS)	75 ug/l		
LEAD	200.7	42 ug/l	34	31
	(ICP)	47.7 ug/l	5	4.4
	239.1	12 ug/l	5.9	17
	(FLAME AA)	105 ug/l	6.7	-1.9
	239.2	10 ug/l	53	-22
	(FURNACE AA)	234 ug/l	19	-3.1

a. Source: Draft Compendium of Information and Performance Data on Routinely Used Measurement Methods (RUMM) - Pilot Phase, RTI/3087/03, prepared for EPA Quality Assurance Management Staff, January 1986. This document should be consulted for more information on individual analytes.

TABLE A-1-C: HISTORICAL PRECISION AND ACCURACY DATA/WATER
(Continued)

LEVEL III SW-846 METHODS

Method Number	Method Name	Data Source	Range of Recovery (%)	Precision (%)	MDL (mg/l)
ORGANICS:					
8010	Halogenated Volatile Organics	SW 846	75.1 - 106.1	2.0 - 25.1	0.03 - 0.52
8020	Aromatic Volatile Oranics	SW 846	77.0 - 120	9.4 - 27.7	0.2 - 0.4
8030	Acrolein, Acrylonitrile, Acetonitrile	SW 846	96 - 107	5.6 - 11.6	0.5 - 0.6
8040	Phenols	SW 846	41 - 86	7.9 - 16.5	058 - 2.2
8060	Esters	EPA 606	82 - 94	1.3 - 6.5	0.29 - 3.0
8080	Organochlorine Pesticides and PCBs	SW 846	86 - 97	1.3 - 6.5	0.29 - 3.0
8090	Nitroaromatics and Cyclic Ketones	SW 846	63 - 71	3.1 - 5.9	0.06/ND
8100	Polynuclear Aromatic Hydrocarbons		NA[b]	NA	NA
8120	Chlorinated Hydrocarbons	SW 846	76 - 99	10 - 25	0.03 - 1.34
8140	Organophosphorous Pesticides	SW 846	56.5 - 120.7	5.3 - 19.9	0.1 - 5.0
8150	Chlorinated Herbicides	SW 846	NA	NA	0.1 - 200
8240	Volatile Organics	SW 846	95 - 107	9 - 28	1.6 - 6.9
8250	GC/MS Semivolatiles (Packed Column)		41 - 143	20 -145	0.9 - 44
8040	GC/MS Semivolatiles (Capillary)		NA	NA	NA

TABLE A-1-C: HISTORICAL PRECISION AND ACCURACY DATA/WATER
(Continued)

LEVEL III SW-846 METHODS

Method Number	Method Name	Data Source	Range of Recovery (%)	Precision (%)	MDL (mg/l)
8310	Polynuclear Aromalic Hydrocarbons (HPLC) (Capillary)	SW 846	78 - 116	7.3 - 12.9	0.03 - 2.3
INORGANICS:	Metals (ICAP)	EPA 200.7	NA	3 - 21.9 (RSD)	1.3 - 75 Mg/l
	Metals (FLAME) 7000 Series	EPA 200	NA	NA	0.01 - 5
7000 Series	Metals (FLAME LESS/GF)	EPA 200	NA	NA	0.001 - 0.2 Mg/l
7470	Metals (MERCURY)	EPA 245.2	87 - 125	0.9 - 4.0	0.0002
9010	Cyanides	EPA 335.2	85 - 102	0.2 - 15.2	0.02 Mg/l
9030	Sulfides	EPA 376.1	NA	NA	1 Mg/l

a. For water only

b. NA Not Available

NOTES: Method Detection Limit (MDL) as listed on this table is the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero.

Accuracy, presented as an average percent recovery, was determined from replicate (10-25) analyses of water and wastewater samples fortified with known concentrations of the analyte of interest at or near the detection limit. In most cases this was less than 10 times the MDL.

Precision data are used to measure the variability of these repetitive analyses reported as a single standard deviation or, as a percentage of the recovery measurements. For presentation purposes accuracy, precision and MDL information is presented as an average range of individual values for every analyte covered by the procedure. If specific information on a particular compound is required, the specific analytical method cited should be consulted.

TABLE A-1-D: HISTORICAL PRECISION AND ACCURACY DATA/WATER[a]

LEVEL IV ANALYTICAL TECHNIQUES - CLP RAS METHODS

ANALYTES	TECHNIQUE	CONCENTRATION RANGE	PRECISION % RSD	ACCURACY % Bias
Volatiles[b]	Purge & Trap GC/MS	N.A.[c]		
Methylene chloride			56	+36.6
1,1-Dichloroethene			20	-26.3
1,1-Dichloroethane			13	-46.4
Trans-1,2-Dichloroethene			31	-21.7
Chloroform			12	-21.1
1,2-Dichloroethane			13	+2.4
1,1,1-Trichloroethane			19	-41.0
Carbon Tetrachloride			12	-32.1
1,1,2,2-Tetrachloroethane			11	-5.8
Bromodichloromethane			19	-13.0
1,2-Dichloropropane			18	-12.9
Trans-1,3-Dichloropropene			31	-41.2
Trichloroethene			17	-22.8
Dibromochloromethane			14	-3.3
1,1,2-Trichloroethane			11	-7.0
Benzene			12	-3.3
Cis-1,3-Dichloropropene			22	-35.5
Bromoform			16	+6.5
Tetrachloroethene			13	-42.5
Toluene			14	-23.3
Chlorobenzene			14	-15.9
Ethyl Benzene			4	-31.9
Semivolatiles[d]	GC/MS	N.A.[c]		
bis(2-Chloroethyl)ether			24	-16
2-Chlorophenol			29	-21
1,3-Dichlorobenzene			24	-48
1,4-Dichlorobenzene			21	-25
1,2-Dichlorobenzene			29	-28
2-Methylphenol			29	-30
bis(2-Chloroisopropyl)ether			25	-22

TABLE A-1-D: HISTORICAL PRECISION AND ACCURACY DATA/WATER

LEVEL IV ANALYTICAL TECHNIQUES - CLP RAS METHODS

ANALYTES	TECHNIQUE	CONCENTRATION RANGE	PRECISION % RSD	ACCURACY % Bias
Semivolatiles[d]	GC/MS	N.A.[c]		
4-Methylphenol			33	-36
N-Nitroso-di-n-propylamine			31	+0.3
Nitrobenzene			32	-23
Isophorone			23	-8
2-Nitrophenol			30	-21
bis(2-Chloroethoxy)methane			34	-2.6
2,4-Dichlorophenol			29	-20
1,2,4-Trichlorobenzene			30	-47
Naphthalene			44	-38
4-Chloro-3-methylphenol			26	-32
2,4,6-Trichlorophenol			25	-17
2-Chloronapthalene			24	+3.4
Acenapthene			28	-12
2,4-Dinitrophenol			24	-23
2,4-Dinitrotoluene			34	-33
2,6-Dinitrotoluene			25	-48
4-Chlorophenyl-phenylether			34	+12
Fluorene			25	-24
4,6-Dinitro-2-methylphenol			30	-13
4-Bromophenyl-phenylether			32	-0.1
Hexachlorobenzene			36	-42
Pentachlorophenol			31	-24
Phenanthrene			21	-28
Fluoranthene			42	-15
Benzo(b)fluoranthene			39	-10
Benzo(a)pyrene			42	-29

TABLE A-1-D: HISTORICAL PRECISION AND ACCURACY DATA/WATER
(continued)

LEVEL IV ANALYTICAL TECHNIQUES - CLP RAS METHODS

ANALYTES	TECHNIQUE	CONCENTRATION RANGE	PRECISION % RSD	ACCURACY % Bias
Metals[e]				
Aluminum	ICP	1000-3000 ug/l	9.1	-4.3
Antimony	ICP	180-600 ug/l	11	-9.2
Arsenic	Furnace AA	50-150	9.4	-8.3
Barium	ICP	800-1500	6.8	-3.9
Beryllium	ICP	30-45	15	+3.7
Cadmium	ICP	25-50	12	-3.3
Calcium	ICP	1000-30000	6.0	-1.6
Chromium	ICP	50-150	9.8	-2.6
Cobalt	ICP	200-1000	6.7	-2.9
Copper	ICP	125-250	6.7	-1.1
Iron	ICP	200-800	10.4	+6.5
Lead	Furnace AA	30	32	-0.7
Magnesium	ICP	10000-40000	6.6	-2.5
Manganese	ICP	30-150	6.2	-1.0
Mercury	Cold Vapor	5-20	18.8	-14.4
Nickel	ICP	160	9.0	-2.5
Potassium	ICP	10000-20000	16.2	-12.1
Selenium	Furnace AA	50	8.7	-5.7
Sodium	ICP	10000-45000	8.7	-2.8
Thallium	Furnace AA	80-100	17.7	-4.2
Tin	ICP	160	N.A.[c]	-2.5
Vanadium	ICP	60-200	7.6	-0.46
Zinc	ICP	50-800	9.1	+3.0

a. Source: Quality Control in Remedial Site Investigation: Hazardous and Industrial Solid Waste Testing, Fifth Volume, ASTM STP 925, C.L. Perket, Ed., American Society for Testing Materials, Philadelphia, 1986.

b. Volatile precision and accuracy data from 26-34 laboratories' results on quarterly blind performance evaluation samples; 29-152 data points for each compound.

c. N.A. = Not Available.

d. Semivolatile precision and accuracy data from 1985 preaward program data; 22-227 data points for each compound.

e. Metals precision and accuracy data is based on performance evaluation sample results from 18 laboratories; number of data points is not given.

TABLE A-2-A: HISTORICAL PRECISION AND ACCURACY DATA/SOILS

LEVEL I FIELD SCREENING TECHNIQUES

MEASUREMENT	INSTRUMENT (TECHNIQUE)	INSTRUMENT RANGE	INSTRUMENT PRECISION [b]	INSTRUMENT ACCURACY [c]
RESISTIVITY	Bison 2390 T/R (Resistivity meter)	0-1999 millivolts	at 1% range setting, 0-5% of full scale	2% of measured value
TERRAIN CONDUCTANCE	EM 31 (conductivity)	0-1000 millimhos/meter	2% of full scale	5% at 20 millimhos/meter
TERRAIN CONDUCTANCE	EM 34-3 (conductivity)	0-300 millimhos/meter	2% of full scale	5% at 20 millimhos/meter
Magnetic Field Intensity	EDA - Omni IV (Magnetometer)	18000-110000 gammas	0.02 gamma	1 gamma at 50000 gammas at 23oC
Subsurface Lithology Changes	SIR-8 (Ground Penetrating Radar)	1-81 dielectric constant	N/A[d]	N/A[d]
Subsurface Lithology Changes	EG+G 1225 (Seismograph)	0-2000 milliseconds	N/A[d]	0.01%

TABLE A-2-A: HISTORICAL PRECISION AND ACCURACY DATA/SOIL[a] (continued)

LEVEL I FIELD SCREENING TECHNIQUES

MEASUREMENT	INSTRUMENT (TECHNIQUE)	FIELD SCREENING RESULTS in ppm (X)	CLP RESULTS in ppm (Y)	ACCURACY[e] (% Bias)
TOTAL VOLATILE ORGANICS	PHOTO VAC (GC/Photoionization)	11.4	26.9	-57.6
		22.0	32.8	-32.9
		56.0	129.7	-56.8
		139	228.0 & 258.0	-42.8
		70.0	126.7	-44.8
		24.9	2823.0	+99.1
		60.0	53.3	+12.6
		6.6	0.056	+116.9
		12.1	0.032	+377.1
		8.7	0.024	+361.5

a. Source: Manufacturers' manuals unless otherwise cited. Mention of specific models does not constitute and endorsement of these instrument.

b. Precision refers to reproducibility of meter or instrument reading as cited in instrument specifications.

c. Accuracy refers to instrument specifications unless otherwise cited.

d. N.A. = not available.

e. Accuracy of PhotoVac field screening results calculated by assuming that CLP results on the same samples were completely accurate. $\% \text{ Bias} = 100 \frac{(X-Y)}{Y}$. Source of these data is CDM project files.

TABLE A-2-B: HISTORICAL PRECISION AND ACCURACY DATA/SOIL[a]

LEVEL II FIELD TECHNIQUES

ANALYTES	INSTRUMENT (TECHNIQUE)	FIELD RESULTS IN ppm (x)	CLP RESULTS IN ppm (y)	ACCURACY[b] % BIAS
PCBs	HNu 301	6.0	22.0	-72.7
	(GC/ELECTRON	6.0	6.1	-1.6
	CAPTURE)	6.0	510.0	-98.8
		9.0	3.9	+56.7
		13.0	3.0	+333.3
		14.0	3.1	+351.6
		14.0	23.5	-40.4
		21.0	8.1	+159.3
		35.0	7.7	354.5
		41.0	2.1	+1,852
		48.0	11.0	+336.3
		50.0	460.0	-89.1
		65.0	23.1	+181.4
		67.0	18.7	+258.3
		92.0	75.0	22.7
		95.0	30.0	+216.7
		11	12.3	-10.6
		202	99.0	+104.0
		269	370.0	-27.3
		286	80.5	+255.3
		1215	640.0	+90.0
		1647	1040.0	+58.4
		3054	9,300	-67.2.

a. Source: CDM Project files.

b. Source: Accuracy calculated by assuming that CLP results on the same samples were completely accurate. % Bias = 100 $\frac{(x-y)}{y}$

TABLE A-2-C: HISTORICAL PRECISION AND ACCURACY DATA/SOIL[a]

LEVEL III ANALYTICAL TECHNIQUES - METHODS OTHER THAN CLP RAS METHODS

ANALYTE	METHOD (TECHNIQUE)	CONCENTRATION RANGE	PRECISION % RSD	ACCURACY % BIAS
DIOXINS	8280	5 ppb	6-30	N.A.
	(HPLC/LRMS)	125 ppb	3-10	N.A.
	JAR EXTRACTION GC/MS	1 ppb	20	0
		10 ppb	10	-18

a. Source: Draft Compendium of Information and Performance Data on Routinely Used Measurement Methods (RUMM) - Pilot Phase, RTI/3087/03, prepared for EPA Quality Assurance Management Staff, January 1986. This document should be consulted for more information on individual analytes.

TABLE A-2-D: HISTORICAL PRECISION AND ACCURACY DATA/SOILS[a]

LEVEL IV ANALYTICAL TECHNIQUES - CLP RAS METHODS

ANALYTES	TECHNIQUE	CONCENTRATION RANGE	PRECISION % RSD	ACCURACY % Bias
Volatiles[b]	Purge & Trap GC/MS	N.A.[c]		
Chloroform			8.0	-0.1
1,2-Dichloroethane			13.1	+11.1
Dibromochloromethane			35.0	-12.0
Benzene			32.1	-10.3
Bromoform			16.6	-12.1
2-Hexanone			16.6	-45.5
Toluene			13.8	+13.7
Chlorobenzene			21.2	+13.2
Semivolatiles[d]	GC/MS	N.A.[c]		
1,4-Dichlorobenzene			27	-51
Nitrobenzene			21	-48
Isophorone			24	-47
2-Nitrophenol			35	-36
2,4-Dichlorophenol			31	-59
1,2,4-Trichlorobenzene			28	-43
Penta Chlorophenol			17	-48
Pyrene			25	-15
2-Methylnaphthalene			26	-42
bis-(2-Ethylhexyl)phthalate			33	-2
Phenol			38	-27
Acenaphthylene			26	-27
Diethyphthalate			16	-20
Dioxin[e]				
2,3,7,8-TCCD		1-10 ug/kg	15	-11.5

TABLE A-2-D: HISTORICAL PRECISION AND ACCURACY DATA/SOILS[a] (continued)

LEVEL IV ANALYTICAL TECHNIQUES - CLP RAS METHODS

ANALYTES	TECHNIQUE	CONCENTRATION RANGE (ug/kg)	PRECISION % RSD	ACCURACY % Bias
Metals[b]				
Aluminum	ICP	2-22600	14.4	-78.8
Cadmium	ICP	5.5-20	33.3	+2.9
Calcium	ICP	2664-29000	N.A.[c]	-4.2
Chromium	ICP	8.5-29600	7.8	-6.1
Copper	ICP	33-109	11.2	-2.5
Iron	ICP	5028-113000	10.7	-27.0
Lead	Furnace AA	11.5-714	9.2	-2.2
Magnesium	ICP	2428-7799	7.5	-10.6
Manganese	ICP	73.5-785	9.4	-15.1
Mercury	Cold Vapor	1.1-26.5	25.0	-9.1
Nickel	ICP	44-67	15.0	-17.0
Tin	ICP	N.A.[c]	44.1	N.A.[c]
Zinc	ICP	19-1720	5.8	-6.2

a. Source: Quality Control in Remedial Site Investigation: Hazardous and Industrial Solid Waste Testing, Fifth Volume, ASTM STP 925, C.L. Perket, Ed., American Society for Testing Materials, Philadelphia, 1986.

b. Volatiles precision and accuracy data is based on 1985 preaward analysis results from laboratories awarded contracts; 6-14 data points for each compound.

c. N.A. = Not Available.

d. Semivolatiles precision and accuracy data is based on 1985 preaward analysis results; 9-20 data points for each compound.

e. Dioxin precision and accuracy data is based on results of four performance evaluation samples including 120 data points.

f. Metals precision and accuracy data is based on performance evaluation sample results from 18 laboratories; number of data points is not given.

TABLE A-3-A: HISTORICAL PRECISION AND ACCURACY DATA/AIR[a]

LEVEL I FIELD SCREENING TECHNIQUES[b]

ANALYTES	INSTRUMENT (TECHNIQUE)	INSTRUMENT RANGE	INSTRUMENT SENSITIVITY[c]	INSTRUMENT PRECISION[c]
Organics	Century OVA-128 (Flame Ionization)	0.1 - 1000 ppm Methane	0.1 ppm Methane	N.A.[d]
Organics	HNu PI-101 (Photoionization)	0.1 - 2000 ppm Benzene	0.1 ppm Benzene	± 1% of full scale deflection
Organics	AID - 710 (Flame Ionization)	0.1 - 2000 ppm Methane	0.1 ppm Methane	N.A.[d]
Organics	PhotoVac (GC-Photoion-ization)	N.A.	0.001 ppm Benzene	N.A.[d]

a. Source: Manufacturers' manuals unless otherwise cited. Mention of specific models does not constitute an endorsement of these instruments.

b. It is difficult to differentiate between Level I and Level II techniques and instrumentation. Several instruments may be used at both levels.

c. Sensitivity and precision refer to instrument specifications.

d. N.A. = Not Available.

TABLE A-3-B: HISTORICAL PRECISION AND ACCURACY DATA/AIR[a]

LEVEL II FIELD TECHNIQUES[b]

ANALYTES	(TECHNIQUE)	INSTRUMENT RANGE	INSTRUMENT SENSITIVITY[c]	INSTRUMENT PRECISION[c]
Organics Compound-Specific	Miran IB (Infrared)	Compound Dependent, 0-2000 ppm	N.A.[d]	N.A.[d]
Organics, Compound-Specific	Century OVA-128 (GC/Flame Ionization)	1-1000 ppm Methane	N.A.	N.A.
Organics, Compound-Specific	PhotoVac (GC-Photo-ionization)	N.A.	0.001 ppm Benzene	N.A.
Organics, Compound-Specific	SCENTOR (Argon Ionization or Electron Capture)	N.A.	0.001 ppm Benzene	N.A.
Mercury	Gold film Mercury Analyzer	N.A.	less than 0.01 ppm	N.A.

a. Source: Manufacturers' manuals. Mention of specific models does not constitute an endorsement of these instruments.

b. It is difficult to differentiate between Level I and Level II techniques and instrumentation. Several instruments may be used at both levels.

c. Sensitivity and precision refer to instrument specifications.

d. N.A. = Not Available.

TABLE A-3-C: HISTORICAL PRECISION AND ACCURACY DATA/AIR[a]

LEVEL III ANALYTICAL TECHNIQUES - METHODS OTHER THAN CLP RAS METHODS

ANALYTES	METHOD (TECHNIQUE)	CONCENTRATION RANGE	PRECISION % RSD	ACCURACY % BIAS
BENZENE	CRYOGENIC TRAP/GC	3.9 ppb	4.0	N.A.
		93 ppb	5.1	N.A.
	TENAX GC/MS	7.8 ug/m3	11	N.A.
		4.5 ug/m3	21	N.A.
TOLUENE		10.8 ppb	5.11	N.A.
TRICHLOROETHENE		3.5 ppb	4.1	N.A.
		84 ppb	3.7	N.A.
VINYL CHLORIDE		7.8 ppb	6.37	N.A.
LEAD	40 CFR 50, APP G (FLAME AA)	0.6 ug/m3	8.6	0
		8.01 ug/m3	3.9	-3.6

a. Source: Draft Compendium of Information and Performance Data on Routinely Used Measurement Methods (RUMM) - Pilot Phase, RTI/3087/03, prepared for EPA Quality Assurance Management Staff, January 1986. This document should be consulted for more information on individual analytes.

TABLE A-4-C: HISTORICAL PRECISION AND ACCURACY DATA/OTHER MEDIA[a]

LEVEL III ANALYTICAL TECHNIQUES - METHODS OTHER THAN CLP RAS METHODS

ANALYTE	METHOD (TECHNIQUE)	MEDIUM	CONCENTRATION RANGE	PRECISION % RSD	ACCURACY % BIAS
LEAD	6010 (ICP)	OIL WASTE	1.0 mg/kg	3.1	-10
			-2.5 mg/kg	22	-20
		SOLID WASTE	50 mg/kg	10	3.4
			75 mg/kg	3.7	-0.8
	SOLID	SLUDGE	5 mg/kg	2	0
			20 mg/kg	11	55

a. Source: Draft Compendium of Information and Performance Data on Routinely Used Measurement Methods (RUMM) - Pilot Phase, RTI/3087/03, prepared for EPA Quality Assurance Management Staff, January 1986. This document should be consulted for more information on individual analytes.

APPENDIX B

CONTRACT REQUIRED DETECTION LIMITS FOR HSL ANALYSES USING CLP IFB PROCEDURES

TABLE B-1

CLP VOLATILE ORGANIC CRDL

Target compound name	SPCC[b] CCC[c]	Low soil CRDL, µg/kg	Low water CRDL, µg/L	CAS number
Chloromethane	SPCC	10	10	74-87-3
Bromomethane		10	10	74-83-9
Vinyl Chloride	CCC	10	10	75-01-4
Chloroethane		10	10	75-00-3
Methylene Chloride		5	5	75-09-2
Acetone		10	10	67-64-1
Carbon Disulfide		5	5	75-15-0
1,1-Dichloroethene	CCC	5	5	75-35-4
1,1-Dichloroethane	SPCC	5	5	75-35-3
Trans-1,2-Dichloroethene		5	5	156-60-5
Chloroform	CCC	5	5	67-66-3
1,2-Dichloroethane		5	5	107-06-2
2-Butanone		10	10	78-93-3
1,1,1-Trichloroethane		5	5	71-55-6
Carbon Tetrachloride		5	5	56-23-5
Vinyl Acetate		10	10	108-05-4
Bromodichloromethane		5	5	75-27-4
1,1,2,2-Tetrachloroethane	SPCC	5	5	79-34-5
1,2-Dichloropropane	CCC	5	5	78-87-5
Trans-1,3-Dichloropropene		5	5	10061-02-6
Trichloroethene		5	5	79-01-6
Dibromochloromethane		5	5	124-48-1
1,1,2-Trichloroethane		5	5	79-00-5
Benzene		5	5	71-43-2
Cis-1,3-Dichloropropene		5	5	10061-01-5
2-Chloroethyl Vinyl Ether		10	10	110-75-8
Bromoform	SPCC	5	5	75-25-2
4-Methyl-2-pentanone		10	10	108-10-1
2-Hexanone		10	10	591-78-6
Tetrachloroethene		5	5	127-18-4
Toluene	CCC	5	5	108-88-3
Chlorobenzene	SPCC	5	5	108-90-7
Ethyl Benzene	CCC	5	5	100-41-4
Styrene		5	5	100-42-5
Total Xylenes		5	5	N.A.

[a]CRDL values obtained from the IFB WA85-J664 [7].

[b]System Performance Check Compounds (SPCC) are used to check compound instability and degradation in the GC/MS and to insure minimum average response factors are met prior to the use of the calibration curve.

[c]Column Check Compounds (CCC) are used to check the validity of the initial calibration.

Note: Medium soil and water CRDLs are 100 times the low level CRDLs.

SOURCE: Flotard, R.D. et al 1986

TABLE B-2

CLP INORGANIC COMPOUND CRDL,
INSTRUMENT DETECTION LEVEL AND WAVELENGTH

Element	CRDL	Method	N	IDL Mean	IDL Std Dev	Wave-Length (nm)
Al	200	ICP	7	70.7	59.3	309.3
Sb	60	ICP	5	42.3	11.3	217.6
As	10	FAA	18	4.6	2.3	198.7
Ba	200	ICP	5	22.1	31.7	493.4
Be	5	ICP	10	2.3	1.7	312.0
Cd	5	ICP	5	4.0	1.1	228.8
Ca	5000	ICP	7	529	472	317.9
Cr	10	ICP	9	5.8	2.9	267.7
Co	50	ICP	11	11.4	8.5	228.6
Cu	25	ICP	11	9.7	6.5	324.5
Fe	100	ICP	10	27.4	20.9	259.9
Pb	5	ICP	12	2.3	1.2	283.3
Mg	5000	ICP	11	385	449	279.6
Mn	15	ICP	10	5.2	4.6	257.6
Hg	0.2	CV	12	0.2	0.1	253.7
Ni	40	ICP	9	17.8	10.1	232.0
K	5000	ICP	8	668	444	766.5
Se	5	FAA	18	2.8	1.3	196.0
Ag	10	ICP	10	5.4	2.7	328.1
Na	5000	ICP	9	756	864	589.0
Tl	10	ICP	18	4.3	2.4	276.8
Sn	40	ICP	7	23.8	8.4	190.0
V	50	ICP	10	13.1	10.0	292.5
Zn	20	ICP	0	8.3	6.3	213.9

IDL - Instrument Detection Limit (µg/L).
N - Number of laboratories using the most common wavelength.
CRDL - Contract Required Detection Limit (µg/L).

SOURCE: Aleckson, K.A. et al 1986.

TABLE B-3

CLP SEMI-VOLATILE HSL COMPOUNDS AND CRDL

Compound name	SPCC[a] or CCC[b]	Low Soil CRDL, µg/kg	Low Water CRDL, µg/L	CAS Number
Phenol	CCC	330	10	108-95-2
bis(2-Chloroethyl)ether		330	10	111-44-4
2-Chlorophenol		330	10	95-57-8
1,3-Dichlorobenzene		330	10	541-73-1
1,4-Dichlorobenzene	CCC	330	10	106-46-7
Benzyl alcohol		330	10	100-51-6
1,2-Dichlorobenzene		330	10	95-50-1
2-Methylphenol		330	10	95-48-7
bis(2-Chloroisopropyl)ether		330	10	39638-32-9
4-Methylphenol		330	10	106-44-5
N-Nitroso-di-n-propylamine	SPCC	330	10	621-64-7
Hexachloroethane		330	10	67-72-1
Nitrobenzene		330	10	98-95-3
Isophorone		330	10	78-59-1
2-Nitrophenol	CCC	330	10	88-75-5
2,4-Dimethylphenol		330	10	105-67-9
Benzoic acid		1,600	50	65-85-0
bis(2-Chloroethoxy)methane		330	10	111-91-1
2,4-Dichlorophenol		330	10	120-83-2
1,2,4-Trichlorobenzene		330	10	120-82-1
Naphthalene		330	10	91-20-3
4-Chloroaniline		330	10	106-47-8
Hexachlorobutadiene	CCC	330	10	87-68-3
4-Chloro-3-methylphenol	CCC	330	10	59-50-7
2-Methylnaphthalene		330	10	91-57-6
Hexachlorocyclopentadiene	SPCC	330	10	77-47-4
2,4,6-Trichlorophenol	CCC	330	10	88-06-2
2,4,5-Trichlorophenol		1,600	50	95-95-4
2-Chloronaphthalene		330	10	91-58-7
2-Nitroaniline		1,600	50	88-74-4
Dimethylphthalate		330	10	131-11-3
Acenaphthylene		330	10	208-96-8
3-Nitroaniline		1,600	50	99-09-2
Acenaphthene	CCC	330	10	83-32-9
2,4-Dinitrophenol	SPCC	1,600	50	51-28-5
4-Nitrophenol	SPCC	1,600	50	100-02-7
Dibenzofuran		330	10	132-64-9
2,4-Dinitrotoluene		330	10	121-14-2
2,6-Dinitrotoluene		330	10	606-20-2
Diethylphthalate		330	10	84-66-2
4-Chlorophenyl-phenylether		330	10	7005-72-3
Fluorene		330	10	86-73-7
4-Nitroaniline		1,600	50	100-01-6
4,6-Dinitro-2-methylphenol		1,600	50	534-52-1

TABLE B-3

CLP SEMI-VOLATILE HSL COMPOUNDS AND CRDL
(continued)

Compound name	SPCC[a] or CCC[b]	Low Soil CRDL, µg/kg	Low Water CRDL, µg/L	CAS Number
N-Nitrosodiphenylamine	CCC	330	10	86-30-6
4-Bromophenyl-phenylether		330	10	101-55-3
Hexachlorobenzene		330	10	118-74-1
Pentachlorophenol	CCC	1,600	50	87-86-5
Phenanthrene		330	10	85-01-8
Anthracene		330	10	120-12-7
Di-n-butylphthalate		330	10	84-74-2
Fluoranthene	CCC	330	10	206-44-0
Pyrene		330	10	129-00-0
Butylbenzylphthalate		330	10	85-68-7
3,3'-Dichlorobenzidine		660	20	91-94-1
Benzo(a)anthracene		330	10	56-55-3
bis(2-Ethylhexyl)phthalate		330	10	117-81-7
Chrysene		330	10	218-01-9
Di-n-octylphthalate	CCC	330	10	117-84-0
Benzo(b)fluoranthene		330	10	205-99-2
Benzo(k)fluoranthene		330	10	207-08-9
Benzo(a)pyrene	CCC	330	10	50-32-8
Indeno(1,2,3-cd)pyrene		330	10	193-39-5
Dibenz(a,h)anthracene		330	10	53-70-3
Benzo(g,h,i)perylene		330	10	191-24-2

[a]CCC-Calibration Check Compound

[b]SPCC-System Performance Check Compound

Note: Medium soil/sediment contract required detection limits are 60 times the individual low soil/sediment CRDL and medium water contract required detection limits are 100 times the individual low water CRDL.

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SOURCE: Wolf, J.S. et al 1986.